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**WAR DEPARTMENT**

**TECHNICAL MANUAL**

**INSTRUCTION GUIDE**

**STEREOSCOPIC TESTER M1A1**

**March 16, 1942**







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WAR DEPARTMENT,  
WASHINGTON, March 16, 1942.

## INSTRUCTION GUIDE

### STEREOSCOPIC TESTER M1A1

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\*This manual supersedes TM 9-2653, March 27, 1941.

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## SECTION I

## GENERAL

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**1. Scope.**—This manual is published for the information of both the using arms and services and ordnance maintenance personnel. It includes the fundamental theory of the stereoscopic tester M1A1, a detailed description of its parts, and complete instruction for its operation, care, and maintenance. Maintenance operations described may be performed by using arms personnel.

**2. Description.**—*a.* The stereoscopic tester M1A1 is a portable, self-contained instrument consisting of a table model stereoscope complete with the necessary calibrated shaft, slide holder, slides, lighting arrangement, and special target slide.

*b.* The slides are furnished in two series, a modified DB series consisting of 8 of the standard DB series and 3 of the standard IVS series, and the DC series consisting of 23 slides.

**3. Identification.**—*a.* The stereoscopic tester M1A1 is a modification of the stereoscopic tester M1. The particular instrument described in this manual is the Keystone visual safety telebinocular. The old type stand on the M1 that could be adjusted only for height has been replaced by one that can be adjusted for height and reading angle of the stereoscope.

*b.* The calibrated shaft (fig. 1) on the M1A1 is graduated so that the back edge of the slide holder should be placed at the diopter accommodation required, whereas the shaft on the early M1's required the front edge of the holder to be set at the graduation called for.

*c.* The slides used with the M1A1 instrument are the same as the slides used with the M1, with the following exceptions in the DB series:

- (1) Test 1 in the IVS series (fig. 16) is substituted for slide DB-10.
- (2) Tests 6 and 7 in the IVS series (fig. 15) are substituted for slide DB-7.

**4. Functions and limitations.**—*a.* The stereoscopic tester M1A1 is used to test and train stereoscopic range and height finder operators and spotters. The instrument is particularly adapted to the selection and training of new operators. It provides mildly corrective and strengthening exercises for the eyes; it is emphasized that training



with it is beneficial to any operator and should improve his performance regardless of his skill and experience.

*b.* The modified DB series of slides is designed for testing visual acuity, muscular balance, astigmatism, fusion, color blindness, and a small degree of stereo-acuity.

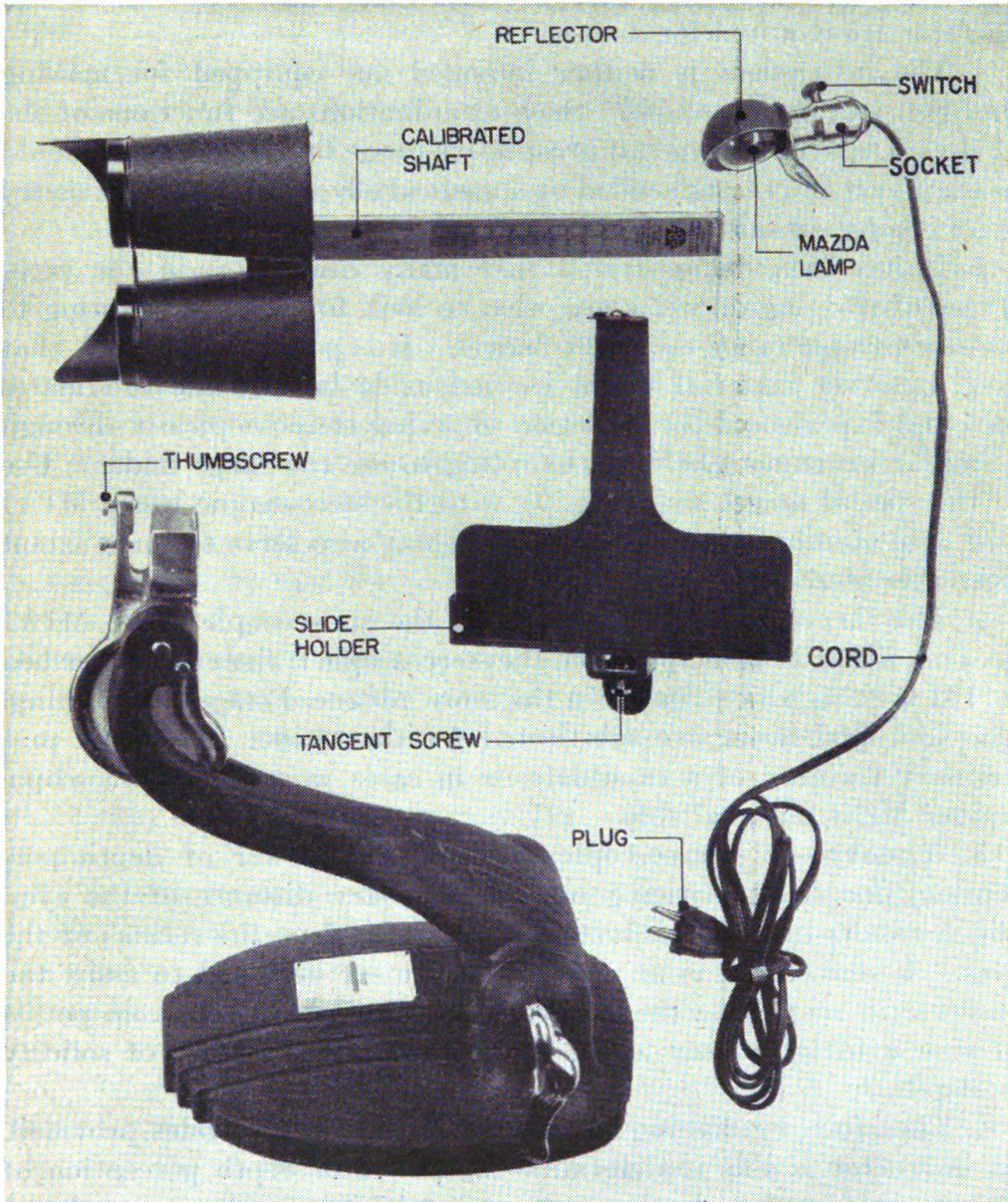


FIGURE 1.—Stereoscopic tester M1A1 disassembled.

*c.* The DC series of slides consists of 23 cards and is designed for testing and training of stereo-acuity with the results measured in percent stereopsis. The even-numbered slides may be used either for

testing or training while the odd-numbered slides should be used solely for supervised tests.

*d.* The tester M1A1 provides a means of training available at all times, being independent of such factors as weather conditions, suitable targets, or the availability of other members of the height finder detail or record section. No personnel other than the instructor and operator are required for its use.

*e.* The instrument is neither intended nor equipped for making thorough eye examinations. Such examinations are functions of the Medical Department, and all prospective range finder operators should be examined and recommended by a medical officer versed in optometry before being considered for further training or retention.

*f.* It has been demonstrated that many candidates in the early stages of training do not know what to look for when attempting to use stereoscopic range or height finders. It is possible, therefore, that good observer material might be cast aside because the candidates have not experienced the sensation of seeing stereoscopically through a similar instrument before attempting to use the range finder. Use of the special target slide (fig. 9) with the stereoscopic tester M1A1 will help eliminate this deficiency. It may also serve to some extent as an exerciser.

*g.* The target slide when used with the stereoscopic tester M1A1 does not differ in principle from the stereoscopic trainer M2, described in TM 9-2654, which is used in the more advanced stages of training. The slide and tester are substituted for the trainer M2 in the preliminary training of a candidate or in cases where the stereoscopic trainer M2 is not available.

**5. Theory.**—*a.* Stereoscopic vision is the power of depth perception, due to the spacing or interpupillary distance of the eyes, which results in different images being formed on the retinas of the eyes. A stereoscope is an optical instrument designed to assist the observer in combining the images of two pictures taken from points of view a little distance apart, and thus to get the effect of solidity or depth.

*b.* Therefore, by making the tests with the various slides provided, an instructor is able to determine the power of depth perception of a prospective operator, the acuteness of his vision or to reveal any abnormal condition of the refracting power of his eyes.



SECTION II

MAJOR UNITS

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**6. General.**—The stereoscopic tester M1A1 (figs. 1 to 3, incl.) consists principally of the optical system (fig. 18), the elements of which are an integral part of, and contained in, the binocular housing; the telebinocular or stereoscope, an adjustable observing instrument which comprises the binocular, slide holder, and lamp; the stereoscopic slides (figs. 11 to 17, incl.) and the special target (fig. 9).

**7. Optical system.**—*a.* The optical system of the stereoscopic tester M1A1 is illustrated in figure 18.

*b.* Each tube of the observing instrument contains a single lens cut in half, known as the eyelens (a decentered spherical lens of +5 diopters or focal length equal to 200 mm).

*c.* The two eyelenses are rigidly mounted with their centers *out*, in such a manner that the distance between their centers is 95 millimeters, hence  $F_r$  and  $F_l$  are the focal points respectively of the right and the left eyelens. Any pencil of light proceeding from these points will emerge from the eyelens parallel to the optical axis.

*d.* Each slide contains the pictures of two targets, the distance between the centers of these pictures depending on the purpose for which they are used. In any case they are arranged to give a fused image.

**8. Telebinocular.**—*a.* The telebinocular or stereoscope (figs. 1 to 3, incl.) consists mainly of the binocular unit with the optical system described above, a card holder mounted on a graduated shaft, an adjustable stand which supports the stereoscope, and the lighting equipment.

*b.* The exterior of the observing instrument (fig. 2) resembles a binocular field glass except for the omission of the mechanism for adjusting the instrument to the interpupillary distance of the observer's eyes. The hood over the eye piece end is shaped so that the distance from the center of the eyelens to the cornea of the eye is about 20 millimeters. Diaphragms, each having a clear aperture 47 millimeters square, are mounted in the front end of each tube in order to limit the field of view of the instrument.

c. The observing instrument is mounted permanently to a calibrated shaft. This shaft (fig. 1) is 250 mm long and is graduated in diopters from +3.25 to -0.50 in divisions of 0.25 diopter. It is also graduated in millimeters from 120 to 220 mm, in divisions of 2 mm, and is numbered every tenth millimeter. The figures in the center

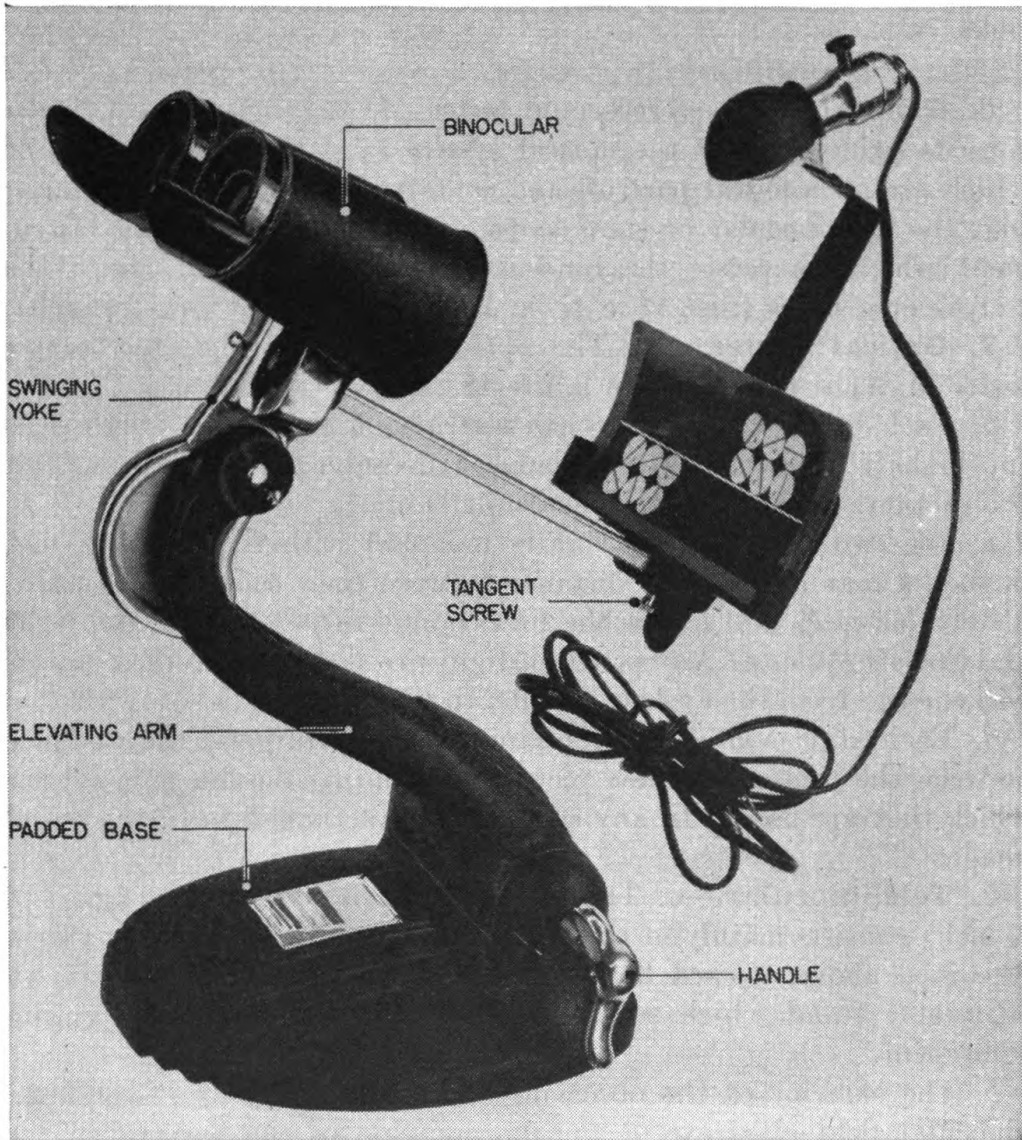


FIGURE 2.—Stereoscopic tester M1A1, with slide.

give the accommodation (in diopters) required in order to see distinctly the pictures on the slide, and the figures on the left represent the equivalent values of the reading distances in inches.

d. The slide holder is provided with a slot at the bottom into which fits the calibrated shaft. The slide holder can be moved to any de-



## STEREOSCOPIC TESTER M1A1

sired position or the shaft and locked by means of the tangent screw. The slide holder is provided with a bracket (fig. 3) to which the lamp is fastened during the test.

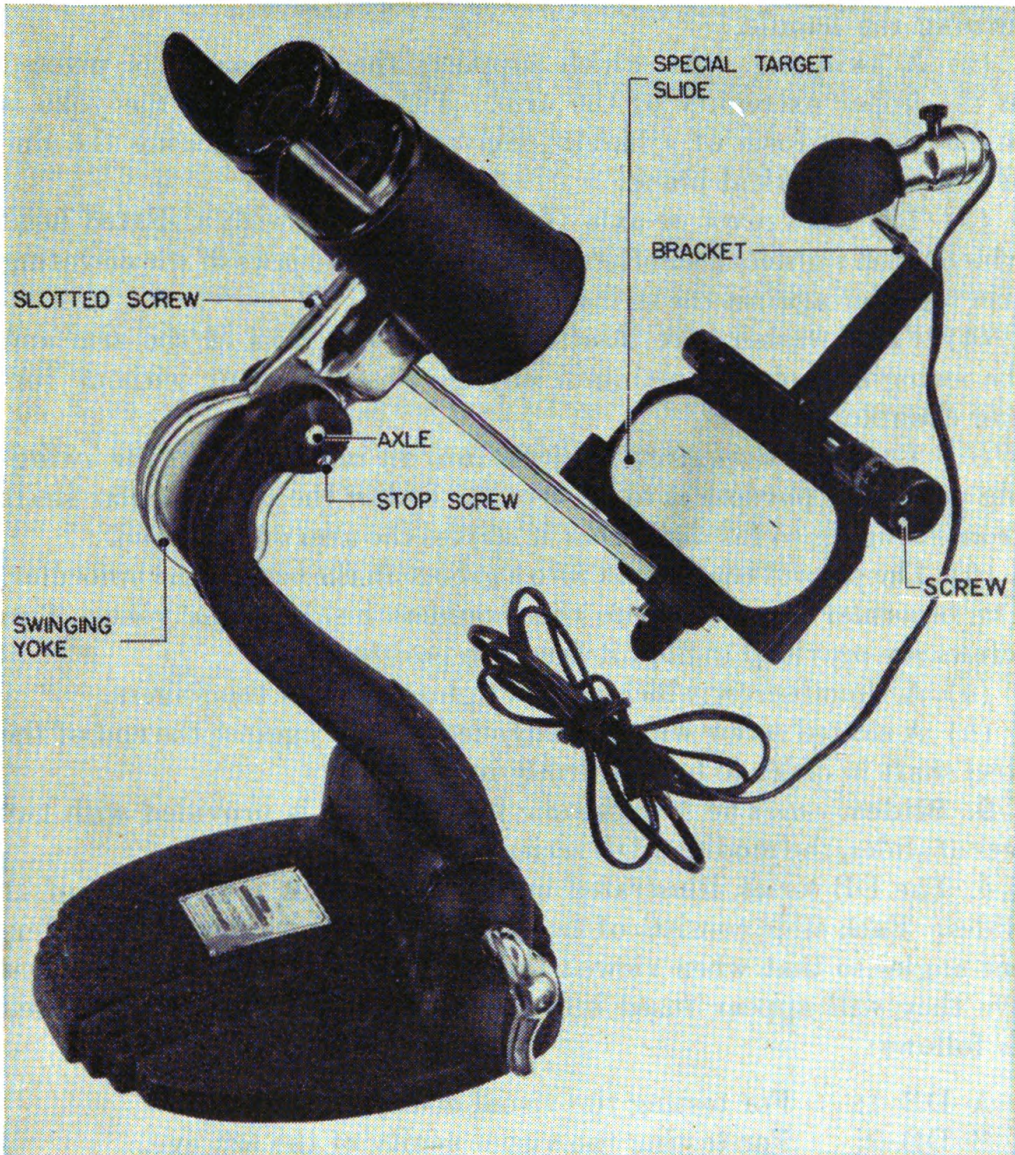


FIGURE 3.—Stereoscopic tester M1A1, with target.

*e.* The lighting equipment consists of a 110-120-volt, 10-watt lamp (fig. 1) complete with an 8-foot, rubber-covered, nonkinking cord, a nonbreakable plug, a lamp socket, switch, and reflector.

*f.* The stand consists of a padded base equipped with an elevating arm for adjusting the height of the stereoscope. The arm is spring-actuated in such a manner as to counterbalance the dead weight of

the arm and stereoscope. The spring is concealed in the base of the elevating arm. (See fig. 2.)

(1) A clamping mechanism is provided to permit locking the arm in any desired position. This mechanism is tightened or released by turning the handle.

(2) A swinging yoke which supports the stereoscope is pivoted in the upper extremity of the arm. The lower end of the yoke is shaped in the form of a handle, convenient for positioning the line of sight in a vertical plane.

(3) The yoke pivot or axle (fig. 3) is a screw with a slotted head which when tightened sufficiently will squeeze the jaws of the elevating arm together against the swinging yoke.

(4) Fiber washers are inserted between the jaws of the arm and the swinging yoke to maintain any given adjustment without further clamping.

(5) The yoke stop screw projects into an impression in the swinging yoke. Its purpose is to prevent the end of the telebinocular shaft from swinging so far down that it strikes the arm of the stand.

(6) The jaws of the yoke fit into a groove in the base of the binocular. The binocular fits down onto the shoulders inside of the yoke. Two screws are provided to hold it firmly in position:

(a) A thumbscrew which can be tightened with the fingers.

(b) A slotted screw which is intended to bear against the end of the steel shaft in order to hold it firmly in position.

**9. Slides.**—*a.* The stereoscopic tester M1A1 is provided with two sets of slides, the modified DB series and the DC series.

*b.* The DB series, illustrated in figures 11 to 16, is composed of 11 slides. Each slide consists of two pictures photographed from different angles so that when viewed through the stereoscope by a normal eye they will appear fused into one picture. These slides are used as follows:

- |          |  |
|----------|--|
| A-DB-1:  | For testing the visual acuity of both eyes.  |
| B-DB-2:  | For testing the visual acuity of the left eye.   |
| C-DB-3:  | For testing the visual acuity of the right eye.  |
| D-DB-4:  | For determining the fusion at distance.  |
| E-DB-8:  | For testing the vertical imbalance (hyperphoria) of the eyes.  |
| F-DB-9:  | For testing the lateral imbalance (phoria) of the eyes.  |
| G-DB-5:  | For determining the fusion at near point.  |
| H-IVS-7: | For determining whether or not there exist any abnormal conditions of the refracting powers of the eyes (ametropia at near point). |



I-IVS-6: For determining whether or not there exist any abnormal conditions of the refracting power of the eyes (ametropia at far point).

J-DB-6: For testing the power of stereoscopic (depth) perception.

K-IVS-1: For testing gross color discrimination (color blindness).

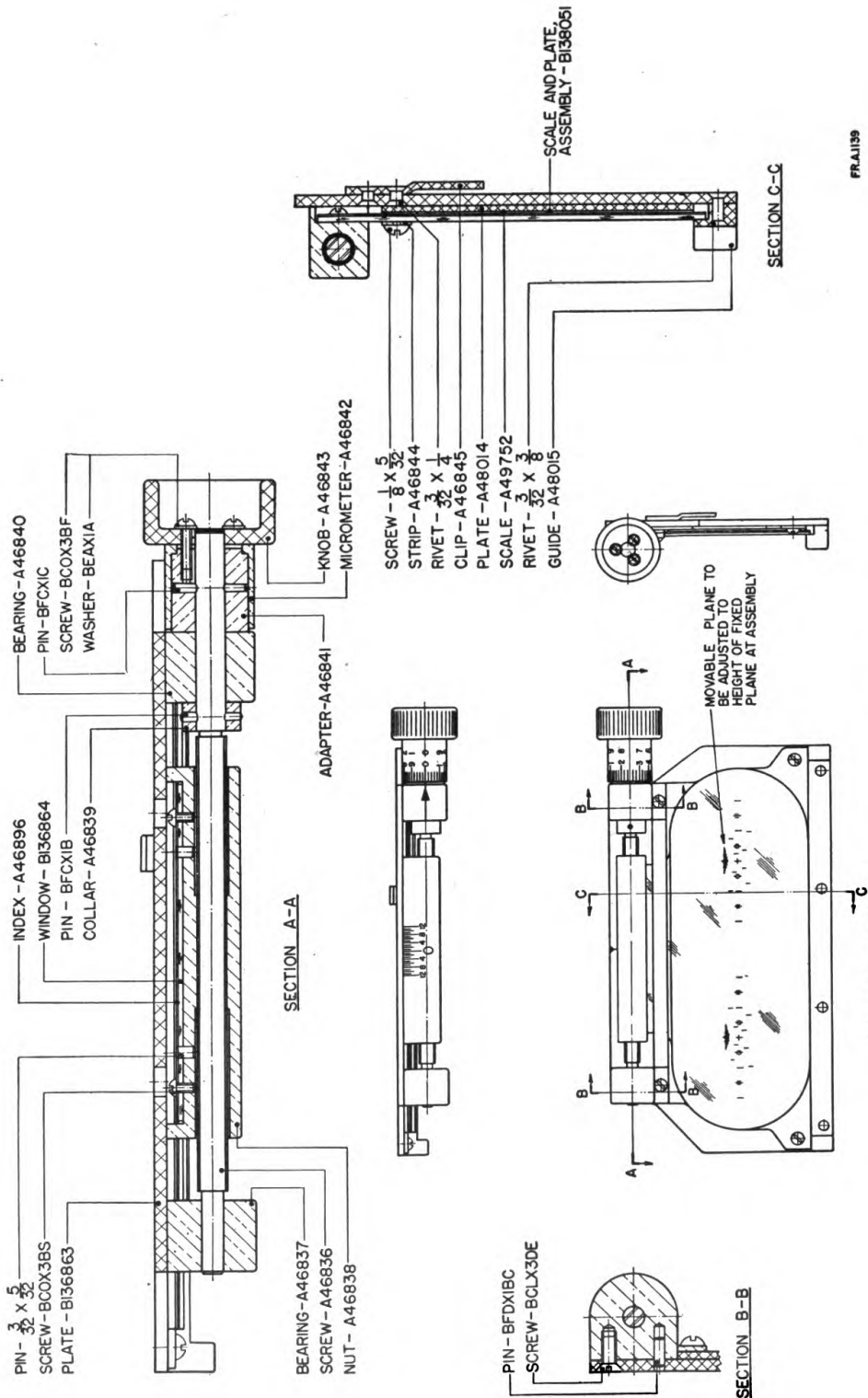
c. The DB series is provided with a pad of record forms (fig. 20). This form gives the correct replies and provides a means of marking and grading the subject.

d. The DC series is composed of 23 slides (fig. 17) and is used for quantitative measurement of stereoscopic perception, that is, the ability to recognize the differences in angles subtended at the eyes by two targets.

e. Each slide contains three rows of various sized numbers and letters. The numbers and letters are of four sizes: 20/25, 20/50, 20/90, 20/120; and are photographed stereoscopically at measured distances, one letter or number in each row being brought forward a definite distance. The slides conform to the following analysis:

Slide No.	Percent stereopsis	Discernible difference of convergence angles (seconds of arc)	Distance of letters or figures from screen (mm)
1-----	1	1, 300	813
2-----	5	870	560
3-----	10	600	406
4-----	15	440	305
5-----	20	360	254
6-----	25	286	203
7-----	30	210	152
8-----	35	175	127
9-----	40	140	100
10-----	45	115	82
11-----	50	95	67
12-----	55	80	56
13-----	60	75	50
14-----	65	65	45
15-----	70	55	38
16-----	75	45	32
17-----	80	39	26
18-----	85	32	21
19-----	90	26	16
20-----	95	21	13
21-----	100	19	10
22-----	105	13	7
23-----	110	10	4

f. This series of slides is provided with a key plate and a pad of record forms (fig. 19).



**TARGET, ASSEMBLY**  
FIGURE 4.—Stereoscopic tester M1A1, target, assembly.



10. **Target.**—*a.* The special target slide (fig. 9) consists principally of a sliding index film fastened to a long rectangular nut; a stereoscopic scale or reticle; and a lead screw mechanism, supported and positioned by bearings at each end.

*b.* The index (A46896, fig. 4) made of Kodalith film has an airplane (known as the target image) on the upper right and is cemented to the back of the window (B136864). The window is fastened to the sliding nut by means of two screws (BCOX3BS) and two pins and is guided by the guide which is riveted to the main plate. The window is also held in place by means of the strip (A46844) which is screwed to the scale plate.

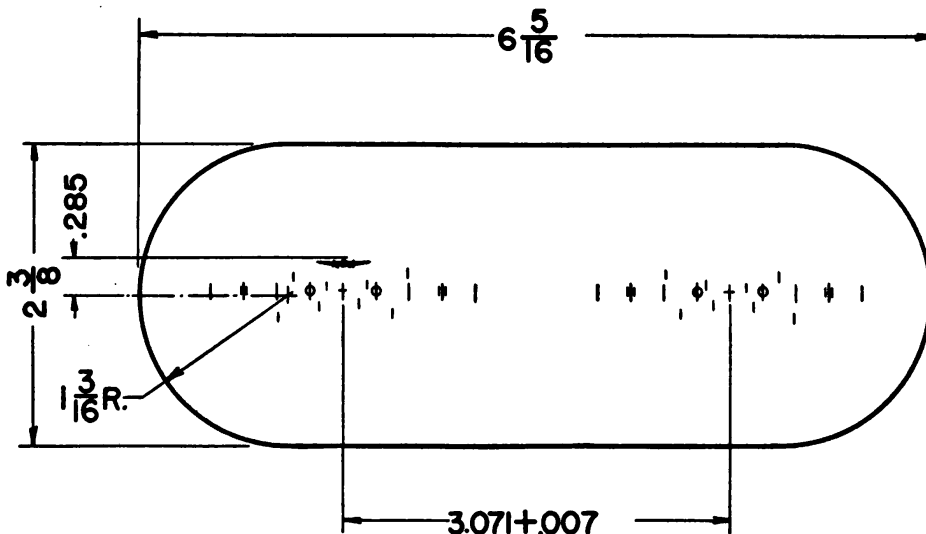


FIGURE 5.—Stereoscopic tester M1A1, stereoscopic scale.

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*c.* The stereoscopic scale (fig. 5), known as the reticle, is cemented to the scale plate (A48104) which in turn is fastened to the main plate by means of four roundhead screws.

*d.* The reticle (fig. 5) is similar to the reticles used in range finders and height finders, consisting of a central measuring mark with an arrangement of auxiliary guiding marks, some in the same depth plane and others in the fore and aft positions. The auxiliary guiding marks serve two purposes.

(1) First, the line of marks in the same depth plane, that is, at the same apparent distance as the central mark, are employed to range on the target when it is not in the center of the field of view

(2) The second purpose of the guiding marks, the marks in a fore and aft position, that is, in advance of and behind the depth plane of the central marks, is to facilitate judgment of the placing of the target in depth by checking its position in the central plane as being midway between corresponding fore and aft marks.

*e.* The reticles when viewed individually show displaced pattern of the upper and lower marks. These displacements give the above described effect of depth when viewed stereoscopically.

*f.* The system of stereoscopic reticle marks on the scale (fig. 5) is shown in figure 6. The line of marks *A-B* all appear in the same depth plane centrally located. The marks along *FCF'* appear in front, that is, nearer to the eye than the central mark *C*. The marks *RCR'* appear in the rear and farther from the eye than the marks in the central plane. When seen through the stereoscope or the range or height finder, the marks appear to be floating in space and are in a symmetrical pattern about the central mark *C*.

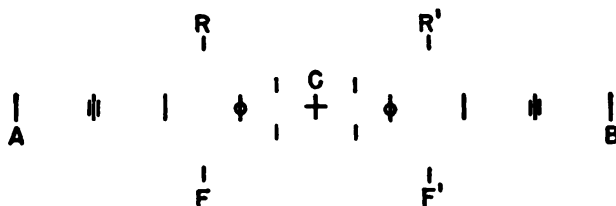


FIGURE 6.—Stereoscopic reticle marks.

*g.* The reticle shows displaced patterns of the upper and lower marks as seen in figure 5. These displacements give the above described effect of depth when viewed stereoscopically. The image of the airplane on the film is displaced for this same reason.

*h.* When viewed through the stereoscope, the image of the airplane on the index film (known as the target image) can be made to fuse with the image of the airplane on the reticle by turning the range knob clockwise or counterclockwise as required. By turning this range knob, the index film moves across the reticle and the target image (airplane) appears to move toward or away from the observer.

*i.* The sliding nut rides back and forth on the lead screw by turning the knob, carrying with it the window and index film. The index film is centered with the stereoscopic scale, that is, the target image appears to be in the same depth plane as the central reticle mark, and is in the center of the field of view when the zero position of the range scale on the nut appears opposite the index on the main plate, and the micrometer reads zero.

*j.* The range scale on the nut is graduated into 24 divisions, 12 to the left of zero and 12 to the right of zero. It is numbered every 4th graduation, 0, 4, 8, and 12. The graduations and numbers to the right are filled in with red whereas the graduations and numbers to the left are in white. The divisions do not have any definite value, but are merely an arbitrary scale so that readings obtained by a subject can be compared from time to time to note his progress. The readings of an individual in the early stages of training may also be compared with those obtained by an experienced observer.

*k.* The lead screw is held and positioned by the two bearings and is pinned to the adapter (A46841, fig. 4). The bearings are fastened to the main plate by means of two flathead screws and two pins. The right bearing has an arrowhead painted on it to serve as an index for the micrometer. The collar (A46839) is pinned to the lead screw to prevent backlash in the mechanism.

*l.* The micrometer fits over the adapter and is clamped between the adapter and the knob (A46843). The knob is fastened to the adapter by means of the three screws (BCOX3BF).

*m.* The micrometer is graduated into 50 divisions, numbered every 5th division from 0 to 9, in two rows of figures, one clockwise, one counterclockwise. Every 5th division equals 0.10 of the unit on the range scale; every division equals 0.02 of the scale unit. The graduations and the numbers on the inside, reading counterclockwise, are painted in white whereas the numbers on the outside, reading clockwise, are painted in red. This numbering and painting of the numbers on the micrometer is necessary so that the micrometer reading will refer to the right or left reading on the range scale.

*n.* The clip (A46845) riveted to the main plate provides a means of holding the target in the slide holder.

### SECTION III

### OPERATION

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**11. Preparation for use.**—*a.* When assembled as in figure 2 or 3 for operation, the stereoscopic tester M1A1 should be placed upon a sturdy, permanently secured table to prevent any damage that might result from upset or collapse of a temporary table. The per-



son taking the test should preferably be seated comfortably before the instrument.

*b.* The instrument should be adjusted to the height of the subject's eyes by means of the clamping arrangement at the foot of the elevating arm (fig. 2). The binocular should be adjusted to a natural reading angle by means of the swinging yoke pivoted in the upper extremity of the elevating arm. It should never be set in a horizontal position.

*c.* After the instrument is adjusted, the lighting arrangement attached to the bracket (fig. 3) should be plugged into any 110-volt a-c or d-c outlet. Adjust the bracket so that the slide is evenly illuminated. All tests should be given in a room where illumination is subdued, with no direct light on the slide except that from the 10-watt bulb of the instrument lamp.

**12. Performing test.**—*a.* The test provides a speedy and precise method of determining whether or not a prospective range finder or height finder operator should be considered for further training. Failure to pass these simple tests indicates the need of a thorough eye examination.

*b.* The subject should be instructed not to remove his head from the hood until the test is completed. Such a movement would necessitate a readjustment of focus of the eyes which would lengthen the time of testing and might invalidate the test.

*c.* The test should be given as rapidly as possible. Hesitancy in replies or replies other than direct answers to the questions of the examiner tend to lower the score of the subject.

*d.* Do not permit the subject to examine any of the slides either in the instrument or out of it except as they are used during these tests.

*e.* Only when verbal instructions are not understood should a pointer be used. Figure 7 shows the correct use of a pointer. The hand of the examiner should rest on the slide holder with the pointer extending steadily straight down. It may be used before the right eye or left eye but should never be extended across from one side to the other.

*f.* Be sure that all slides are level in the slide holder. Do not let any slide rest as shown in figure 8 since this would invalidate the test.

*g.* Two positions on the calibrated shaft are used in giving these tests. The back edge of the slide holder should be placed exactly on the line marked  $\infty-0.0-200$  for all tests taken at the equivalent of optical infinity and exactly on the line marked  $16-2.50-130$  for

all tests taken at the "near point" or the equivalent of 16 inches from the eyes. (0 and 2.50 indicate the amount of accommodation

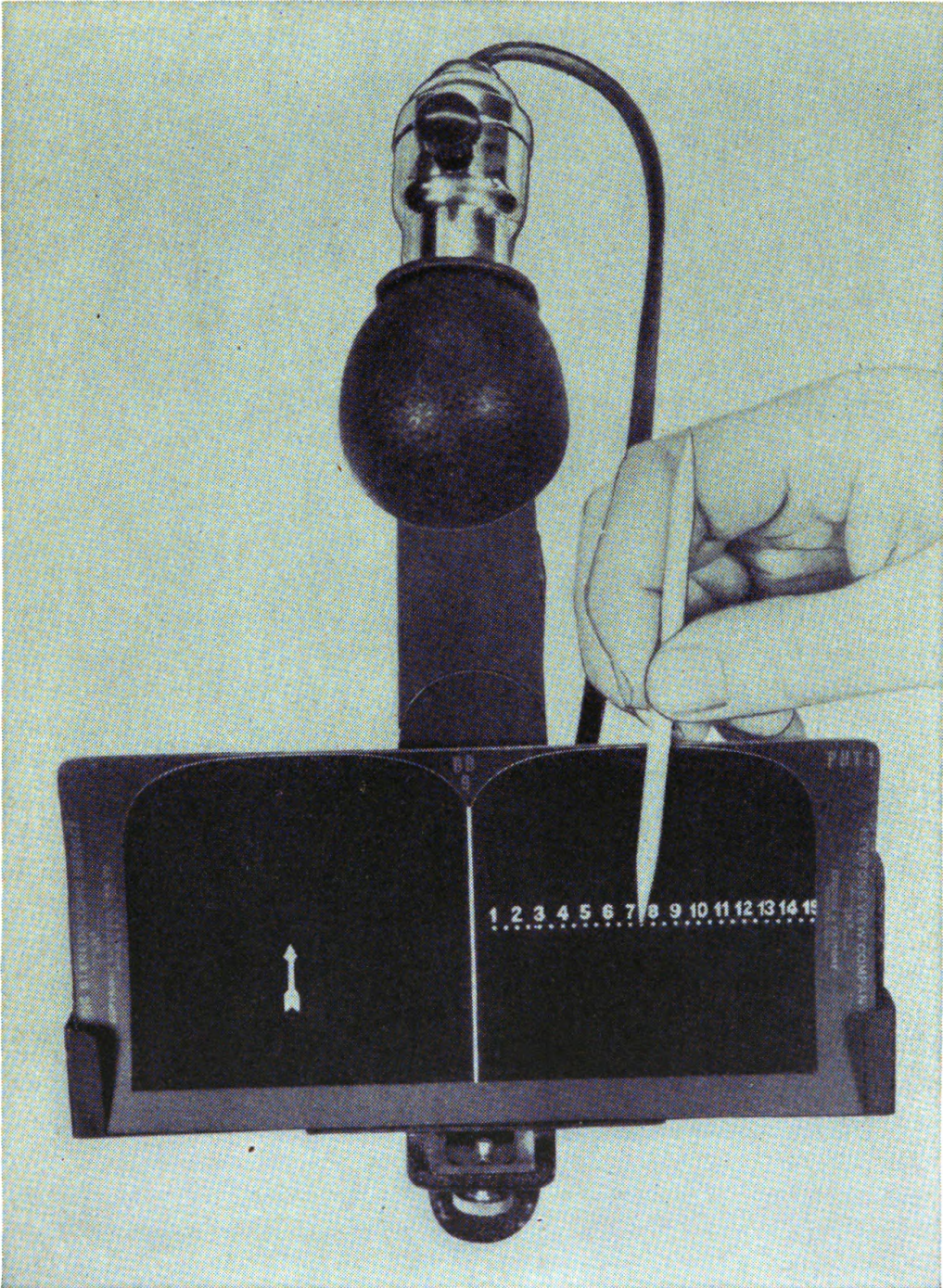


FIGURE 7.—Stereoscopic tester M1A1, use of pointer.

in spherical diopters exercised by normal eyes at these positions, and 200 and 130 (really 133) indicate the distances from lenses to



slide holder in millimeters. Other numbers on the scale have similar significance when the instrument is used for purposes other than the administration of these tests.)

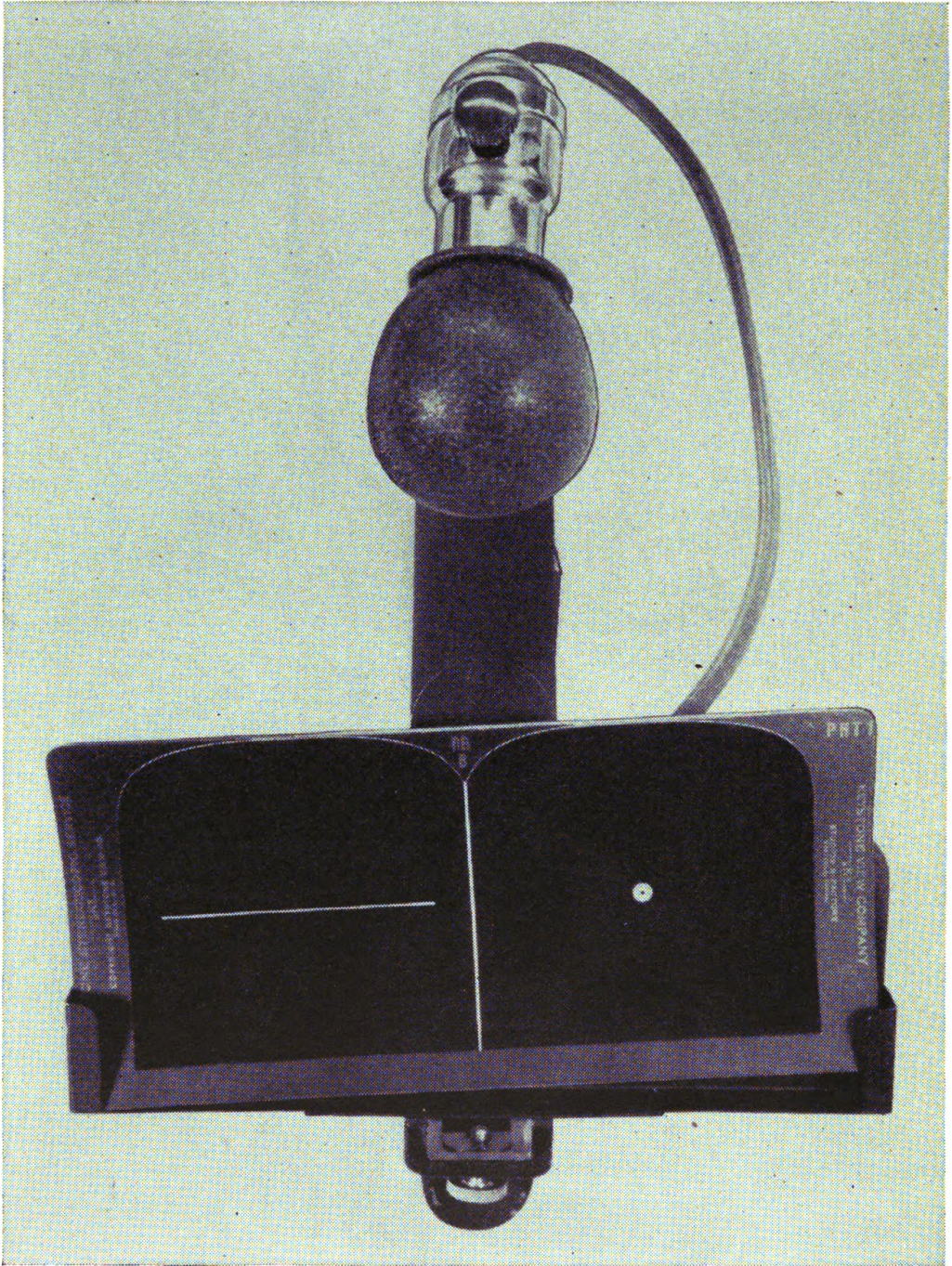


FIGURE 8.—Stereoscopic tester M1A1, incorrect position of slide.

**13. Tests with DB series.**—*a.* The modified DB series of slides, consisting of eight of the standard DB series and three of the



standard IVS series, is designed for testing visual acuity, muscular balance, astigmatism, fusion, color blindness, and a small degree of stereo-acuity.

b. For the greatest efficiency and speed, the slides should be arranged in two groups in the following order which should never be changed:

(1) *Group 1.*

A-DB-1	E-DB-8
B-DB-2	F-DB-9
C-DB-3	G-DB-5
D-DB-4	H-IVS-7

(2) *Group 2.*

I-IVS-6	J-DB-6	K-IVS-1
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c. All the slides in group 1 should be placed in the slide holder, in order, with A-DB-1 nearest the eyes. The other group should be placed face down near the instrument to be used when the tests with group 1 are completed. The slide holder should be set at  $\infty-0$  from which position it should not be moved until test 7. Twelve tests are made as follows:

(1) *Test 1—Visual efficiency, binocular.*—(a) This slide (A-DB-1, fig. 11) shows eleven signboards located at various distances from the observer. Each signboard is made up of five squares arranged in the shape of a cross. One square of each signboard on both halves of the slide is marked by a dot. On the record form (fig. 20) under test 1, there are given the letters, R, L, C, B, and T, which means that the dot is to be found either in right square R, the left square L, the center square C, the bottom square B, or the top square T.

(b) The subject is asked, "Do you see a single woodland scene with a number of signboards at different distances in the woods?" If the answer is "Yes," indicating proper fusion, proceed with the test.

(c) The subject is asked in what square of signboard 1 the dot is found, and the instructor will check the correct answer on his record sheet. This procedure is to be repeated for each successive signboard until the subject hesitates or gives the wrong answer. The correct answers are given on the record form. The last check denotes the percentage of visual acuity for both eyes. For example, if the subject gives the correct position of the dot on signboard 9 or better, then his visual acuity is 100 percent and the instructor will write *passed* in his record. If the correct position of the dot on signboard 8 is given by the subject his visual acuity is 90 percent or *questionable*. A recognition of the correct position of the dot on

signboard 7, or less, is equal to a visual acuity of 80 percent, and the record will be marked *failed*.

(d) If the dot in the first signboard cannot be distinguished, the vision is so low that it is useless to proceed with the test. If there is any difficulty in fusing the two parts of the stereograph, the slide holder may be moved back and forth on the shaft until fused but it must be returned to  $\infty-0$  before the position of the dots is called for.

(e) When the last reply has been given, the examiner should say, "This test is given three times. Give the position of the dots again," meanwhile transferring this slide, A-DB-1, to the back of the pack in the slide holder thus exposing slide B-DB-2.

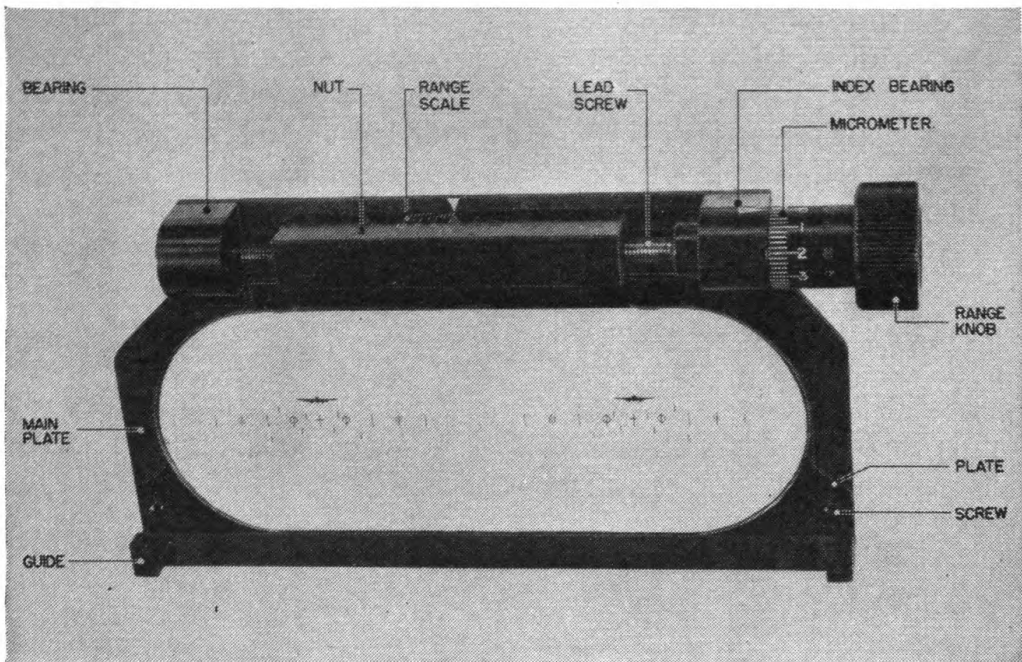


FIGURE 9.—Stereoscopic tester M1A1, special target slide.

(2) *Test 2—Visual efficiency, left eye.*—(a) This slide differs from slide DB-1 in that only the squares presented to the left eye of the subject contain dots, while all the squares presented to the right eye are blank. The procedure of the test is identical with the one employed in the preceding test, and the record forms are marked accordingly.

(b) Should the subject not go as far as on the previous test, check his last correct reply and then cover the end of the right telebinocular barrel and ask, "Now can you see any more dots?" If more dots are now reported, mark the last correct reply with an

O (for occlusion). Such a report indicates suspension of vision in the left eye when both eyes are open. Ordinarily this is a symptom

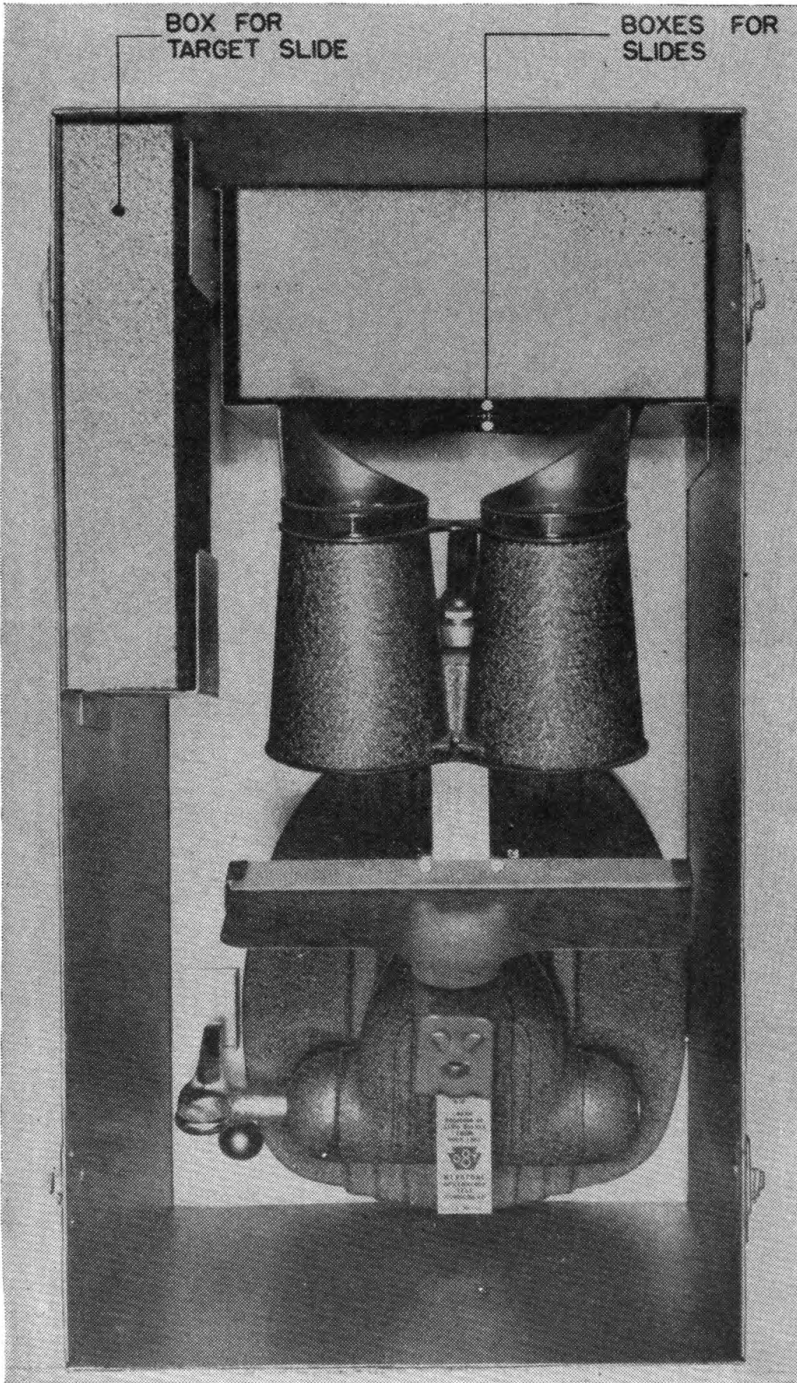


FIGURE 10.—Stereoscopic tester M1A1 in carrying case.

of somewhat inefficient binocular vision, but it might be induced normally by the voluntary suppression of vision of the eye not in use in gun sighting and similar occupations.



(c) When the last dot has been located, transfer this slide to the back of the pack in the slide holder, thus exposing slide C-DB-3 (fig. 12). Say, "Now locate the dots again."

(3) *Test 3—Visual efficiency, right eye.*—(a) This slide has dots in the various squares of the signboards which are presented to the

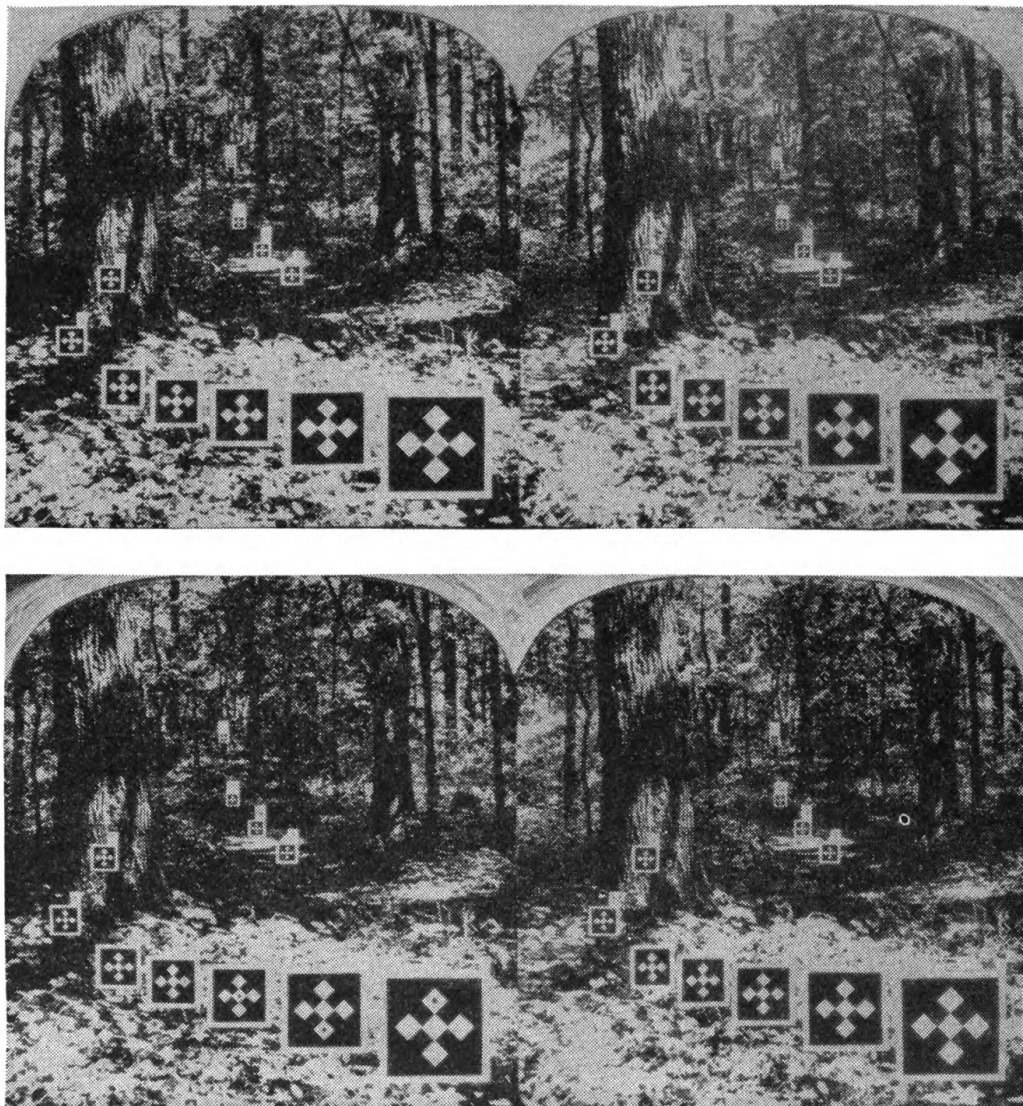


FIGURE 11.—Stereoscopic tester M1A1 slides.

right eye. It is, therefore, a good test for the acuity of the right eye during binocular observation. The test is made in the same manner as in the previous two tests and the recording forms are marked in the same manner, except that if it is necessary to occlude as indicated in (b) above, the left telebinocular barrel should be covered.

(b) As soon as the test has been completed but before the slide has been moved, say "When I remove this slide tell me how many balls you see," then transfer the slide to the back of the pack in the slide holder, thus exposing slide D-DB-4.

(4) *Test 4—Fusion at distance.*—(a) The reply should be immediate, "Three balls" or "Four," then "Three."

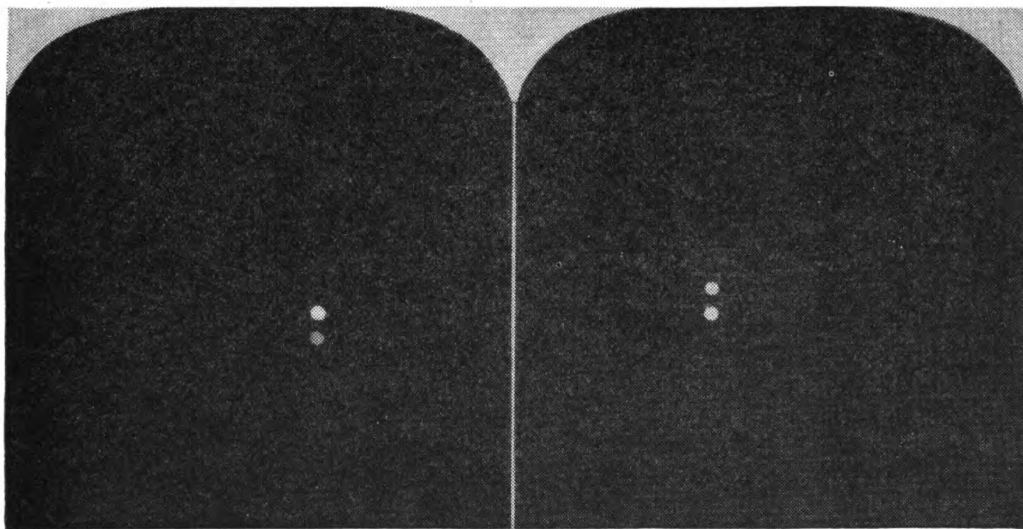
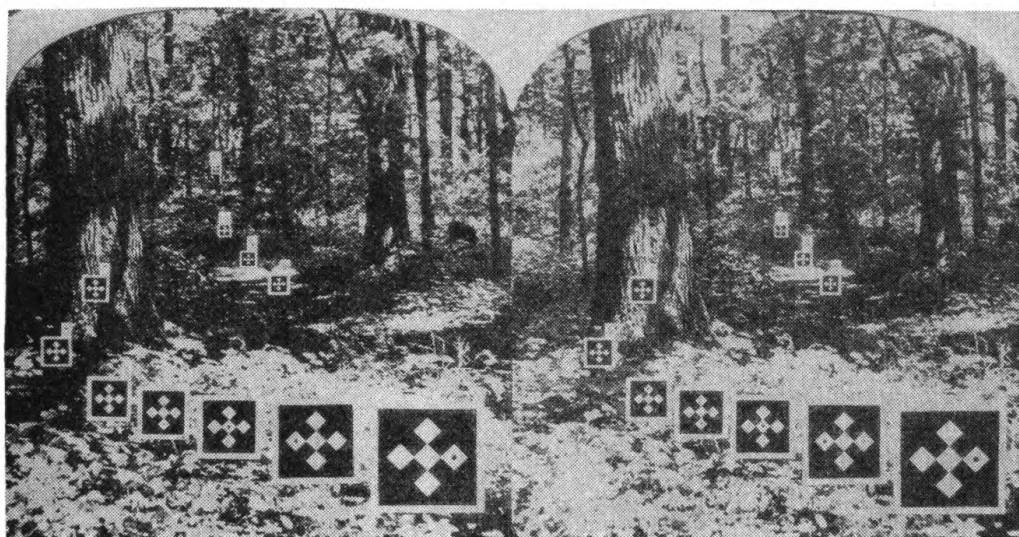


FIGURE 12.—Stereoscopic tester M1A1 slides.

(b) The left side of slide DB-4 (fig. 12) shows one white and one dark blue ball, one above the other, while on the right side of the slide there are seen one red and one light blue ball, also one above the other. The purpose of the slide is to test the power of fusion for small sized objects placed beyond arms reach.

(c) If the subject sees first four and then three, the test is marked *passed*, but if he sees first three and then four, it is not acceptable and should be marked accordingly. Any other reply (see record form) indicates the present or eventual probability of binocular fatigue or suspension at far point. This finding will be confirmed by test 6.

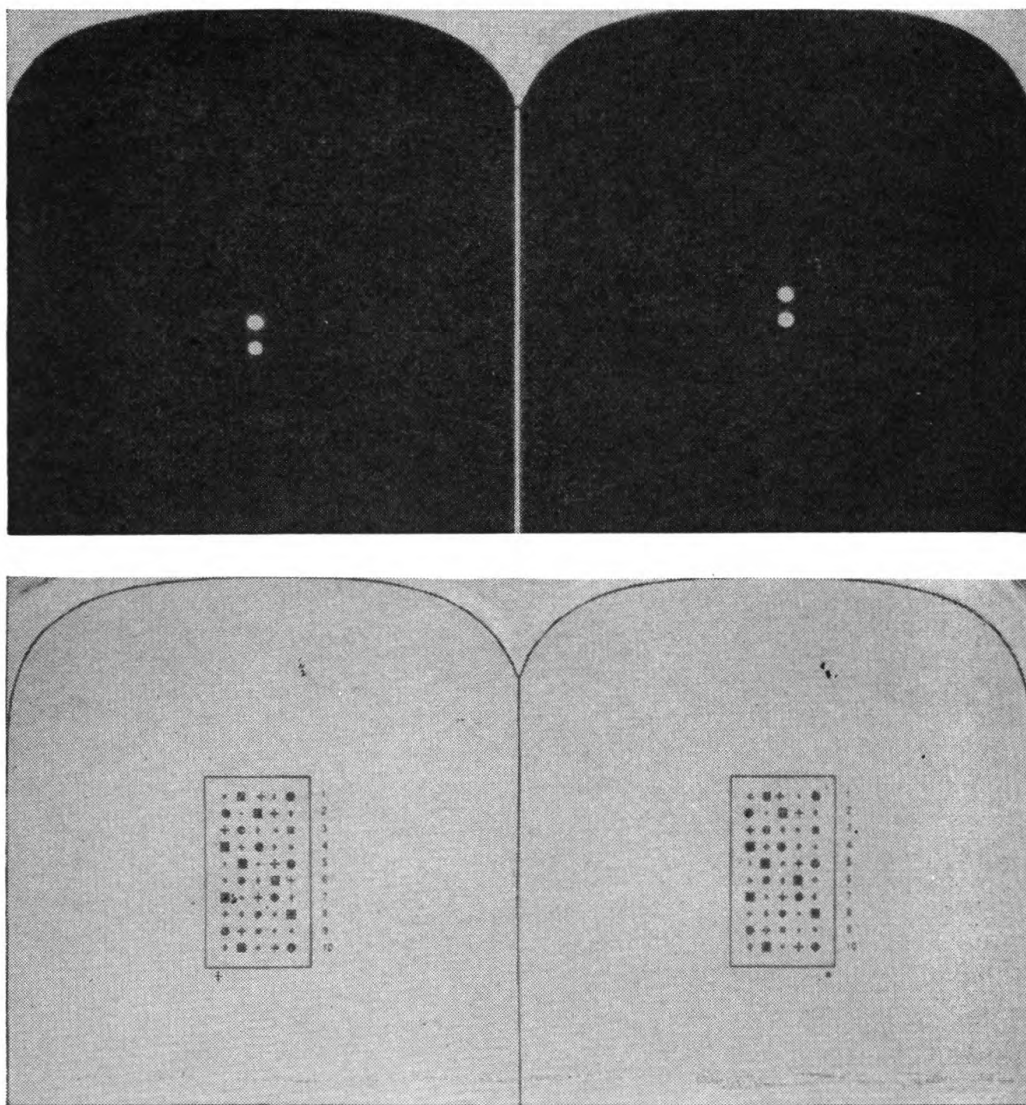


FIGURE 13.—Stereoscopic tester M1A1 slides.

(d) As soon as the number of balls seen has been reported, transfer the slide to the back of the pack in the slide holder thus exposing slide E-DB-8 (fig. 14).

(5) *Test 5—Vertical imbalance.*—(a) This slide has a green horizontal line on its left side and a red ball with a black dot in the



center on its right side. A subject with eyes well balanced in the horizontal plane should see the green line projected upon the black dot in the center of the red ball.

(b) The instructor will ask, "Is the green line entirely above, entirely below, or through the red ball at some point?" If the line passes through the ball at any point the hyperphoria is not greater

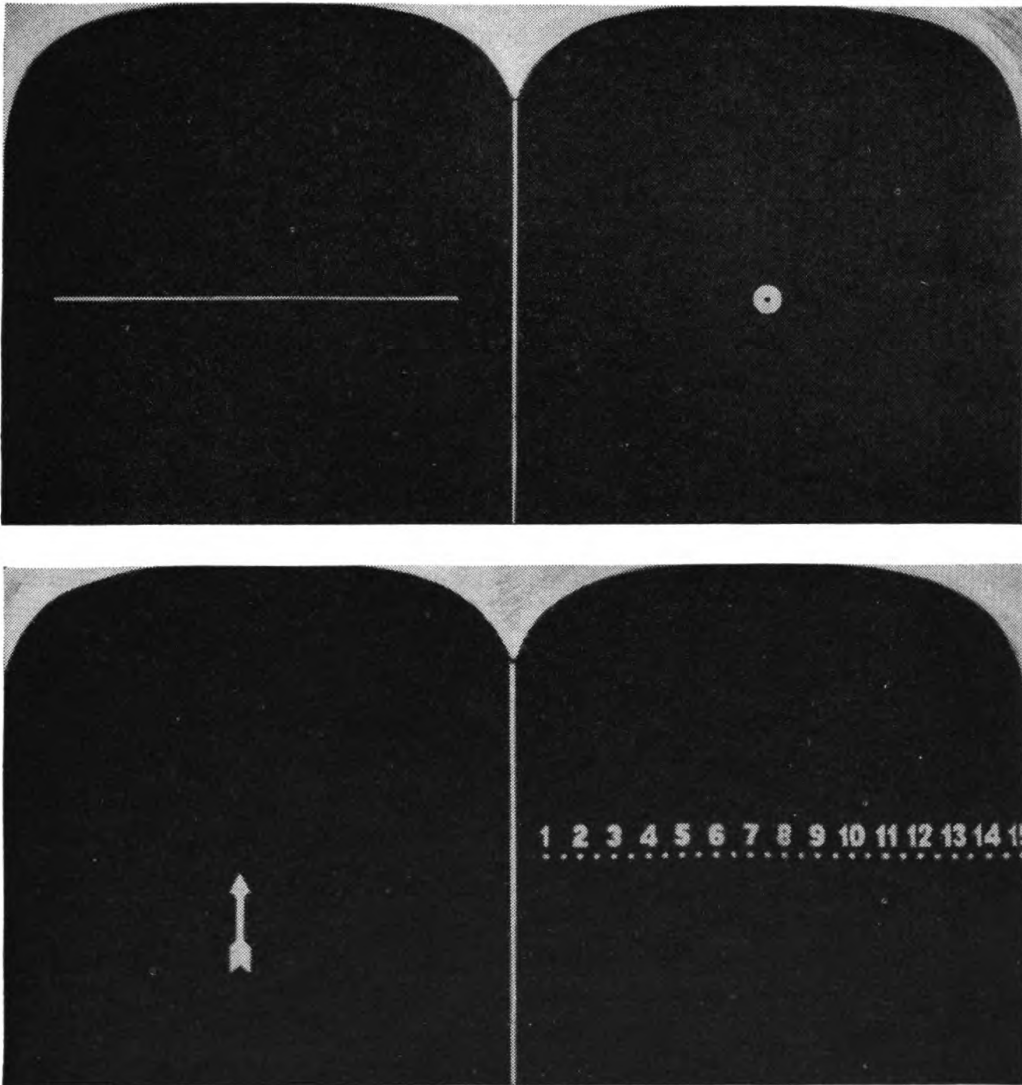


FIGURE 14.—Stereoscopic tester M1A1 slides.

than  $\frac{3}{4}$  prism diopter. If the line does not touch the ball above or below it, note whether subject's head is tilted to one side, or in the event that he is wearing glasses, whether they are bent or do not fit the face properly. When a change in head tilt (if not habitual) or a straightening of the glasses causes the line to pass through the ball the test should be marked *passed*. Otherwise it is *failed*. If

the line is far from the balls, it is doubtful if test 4 could have been passed.

(c) Indicate the condition on the record form by checking the most appropriate diagram. Quite rarely a subject will report that the ball is at one end of the green line. It is useless to proceed in such cases. However, test 6 will confirm this report and may be given at once. As soon as the test is completed transfer the slide to the back of the pack in the slide holder, thus exposing slide F-DB-9 (fig. 14).

(6) *Test 6—Lateral imbalance at far point.*—(a) The instructor will ask, "To what number does the arrow point?" If the subject reports the arrow wavering slightly, simply note the nearest position to which it points. Draw a vertical line through the number on the record form to which the subject reports the arrow pointing.

(b) Normally the arrow should point to 9 but it may point to any number within the tolerance line and still be considered as *passed*. Exophoria is indicated if the arrow is seen to the right of 11 and esophoria is indicated if it is seen to the left of 7. Such responses are considered as *failed*.

(c) The shifting about of the arrow is usually due to variations in accommodation which by reflex cause variations in convergence. Such shifting is usually not significant unless it extends beyond the tolerance line.

(d) As a confirmation of test 4, if the arrow appears within the range of the tolerance line three balls may be reported if fusion is good, but if the arrow is beyond the tolerance line in either direction three balls will seldom be reported. In other words, the farther away from 9 the arrow appears the greater the fusion urge if three balls are seen. This is a favorable symptom. On the other hand, if the arrow is on or near 9 and three balls cannot be seen, fusion urge is considered to be low, an unfavorable symptom.

(e) This slide is not transferred to the back of the pack now as the same slide is used for the next test.

(7) *Test 7—Lateral imbalance at near point.*—(a) The examiner says, "I will now move this slide nearer your eyes which will change the position of the arrow." The slide holder is then moved to 16-2.50 on the shaft. (Persons wearing bifocal glasses should use reading segments on this and all other near point tests.)

(b) When properly placed ask, "To what number does the arrow now point?" The correct reply should be "Five" but the test is considered as *passed* if it is anywhere on the tolerance line as indicated

in the record form. If seen beyond the tolerance line in either direction the test is marked *failed*.

(c) This test will be confirmed by test 8. The explanatory notes under test 6 apply to this test also if referred to a near point situation. It is not uncommon for one test to be passed while the other is failed.

(d) Before removing this slide the examiner says, "As soon as I remove this slide tell me how many balls you see." Then the slide is transferred to the back of the pack thus exposing G-DB-5 (fig. 13).

(8) *Test 8—Fusion at near point.*—(a) The reply should be immediate, "Three balls" or "Four balls," then "Three."

(b) This slide, G-DB-5, is similar in construction to slide D-DB-4 and is used to test the power of fusion when near objects are viewed. Those who have done much close work should pass this test easily.

(c) Failure to pass test 8 indicates the probability of eye fatigue under prolonged near point work. The reported findings are marked under test 8 of the record form in the same manner as under test 4.

(d) Now transfer this slide to the back of the pack, thus revealing slide H-IVS-7 (fig. 15).

(9) *Test 9—Ametropia at near point.*—(a) Slide H-IVS-7 contains 12 balls with black lines running through the balls in different positions.

(b) The examiner asks the question, "In what ball, if any, do you see one heavy but not very black line?" If such a line is reported, ask if the lines in the ball above it or below it are sharp and clear. If the reply is "Yes" check the appropriate pair on the record form and mark it *failed*.

(c) Such a report indicates a probable myopic astigmatism. Many more subjects may be expected to pass this test than will pass test 10.

(d) Now ask, "How many lines in each ball?" Any hesitancy or error in the response, or a report that some or all lines appear blurry, run together, or are hard to count regardless of their relationship in vertical pairs, indicates impaired visual acuity at near point and should be marked *failed*.

(e) Subjects over 40 years of age who fail the tests are probably in need of reading glasses. Note that if reading glasses or bifocals are worn habitually the reading segments should be used in taking this test. If the test is failed when so used the indication is a probable need for change in the prescription.

(f) Now move the slide holder to the outer end of the shaft, transfer this slide to the back of the pack, and remove the entire pack. Place it, face down, on the table. Now place in the slide holder the three slides of group 2 with slide I-IVS-6 nearest the eyes.



(10) *Test 10—Ametropia at far point.*—(a) The instructor says, “Here are 12 yellow balls each crossed by black lines. All these lines are probably blurry or indistinct. You are to tell me in what ball you can see very clear sharp lines and in what ball there appears to

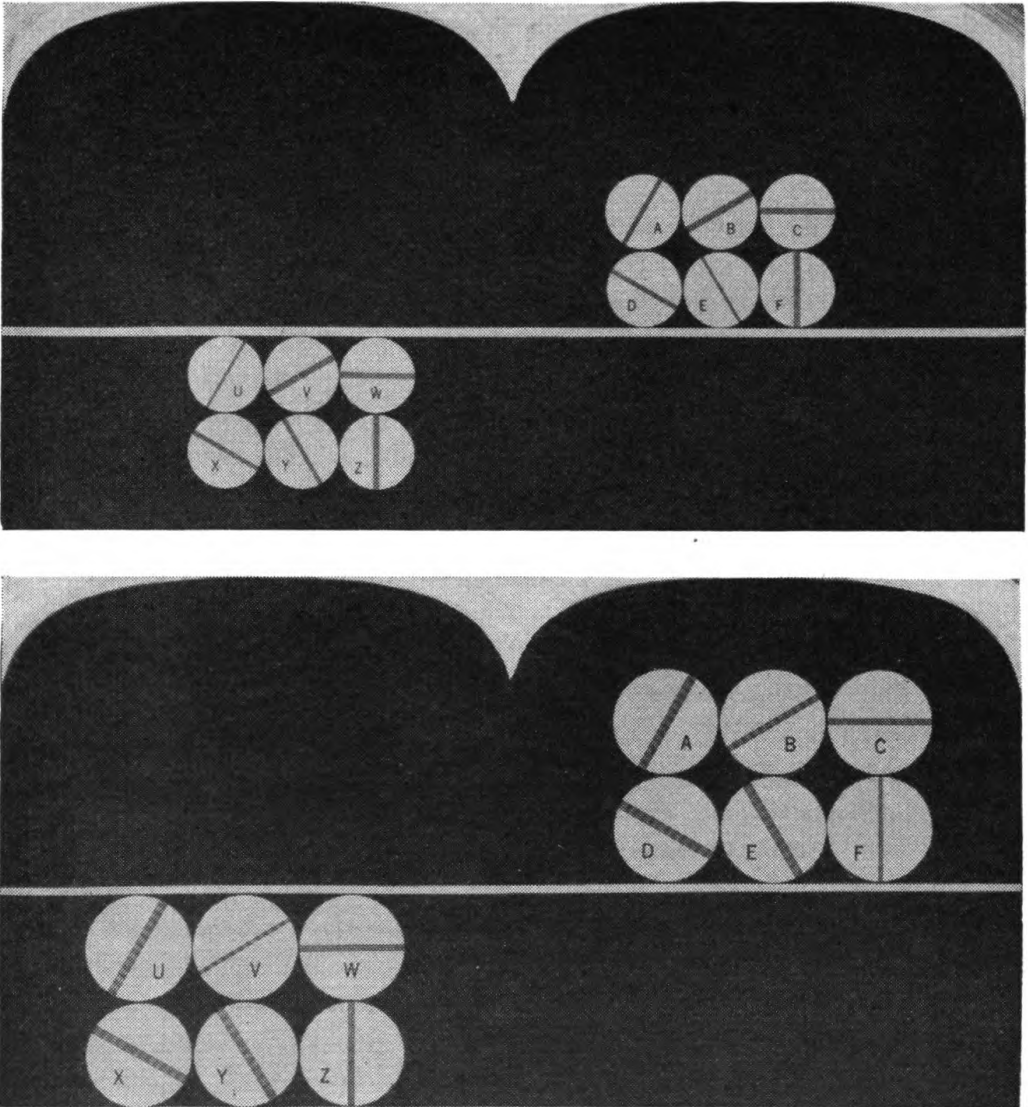


FIGURE 15.—Stereoscopic tester M1A1 slides.

be one heavy but not very black line.” There may be an immediate response, “Clear lines in ball —, one line in ball —.”

(b) If these two balls constitute a vertical pair, as  $\frac{A}{D}$  or  $\frac{B}{E}$  etc., the test is *failed* regardless of how the lines appear on the other balls.

However, it is not uncommon for two adjacent vertical pairs to have the same appearance, as  $\overline{B}$  and  $\overline{C}$  clear.

$\overline{E}$  and  $\overline{F}$  single.

A record of the clear and heavy lines only need be made.

(c) If the lines in all balls seem to be about equally blurry or indistinct when the slide holder is at the end of the shaft, the examiner moves the slide holder slowly toward the subject's eyes, meanwhile repeating the request for the appearance of clear lines and single heavy lines. If all lines are about equally blurry or indistinct before the slide holder reaches  $\infty-0$ , and all lines can be counted when the slide holder is at  $\infty-0$ , even if some are more blurry than others, the test is *passed*.

(d) The only significant answer is, "Clear sharp lines in one ball with a single line in the ball below or above it." If this report is given when the slide holder is at  $\infty-0$  or at any point beyond it the test is *failed*, and the appropriate vertical pair or pairs should be checked on the record form.

(e) The indication is a probable hyperopic astigmatic error.

(f) When the test is completed transfer the slide to the back of the pack thus exposing slide J-DB-6 (fig. 13).

(11) *Test 11—Stereopsis or depth perception.*—(a) Name the objects in the top row to the subject so that he may learn to designate the characters properly. Then say, "Look at the top row carefully; one of the characters stands out toward you, right out in front of the others, which one is it?" As soon as the subject understands the procedure time may be saved by jumping to row 7, then 9 and 10, being sure there is no error in response or too much hesitation.

(b) Check ( $\checkmark$ ) the last correct reply on the record form. Indicate errors with an X, but if the correct reply is given for line 10 give a second trial on lines marked with an X. If now correct, check ( $\checkmark$ ) but leave the X. Such a reply has the same significance as the "Occlusion" check in test 2 and test 3.

(c) When the subject can see the characters standing in front in the rows 1 to 8, his rating will be 80 percent or *failed*; if he also sees the star in the 9th row standing forward then the rating is 90 percent or *questionable*, and if he can see the cross in the 10th row in front of the other characters then his rating is 100 percent or *passed*.

(d) Should the subject fail to report any stereopsis, ascertain if there is binocular vision by asking, "What do you see entirely below the frame or rectangle surrounding the little designs?" Both cross and ball should be reported. If one or the other is missing, a pointer may be used to call attention to the missing design.

(e) Stereopsis is impossible unless both eyes are functioning. An appreciable number of men will fail on this test, who are likely to be unreliable in judging distances.

(f) As soon as the test has been completed, transfer the slide to the back of the pack thus exposing slide K-IVS-1 (fig. 16).

(12) *Test 12—Gross color discrimination.*—(a) The subject should be asked, "Do you see part of a single bridge at the top of this slide and four vertical rows of squares beneath it?" The answer "Yes" signifies that the slide is properly fused, or it might mean that the subject is using one eye, in which event he could still take the test. If the answer is negative the slide holder may be moved up and down the shaft until properly fused. Then return it to  $\infty-0$ .

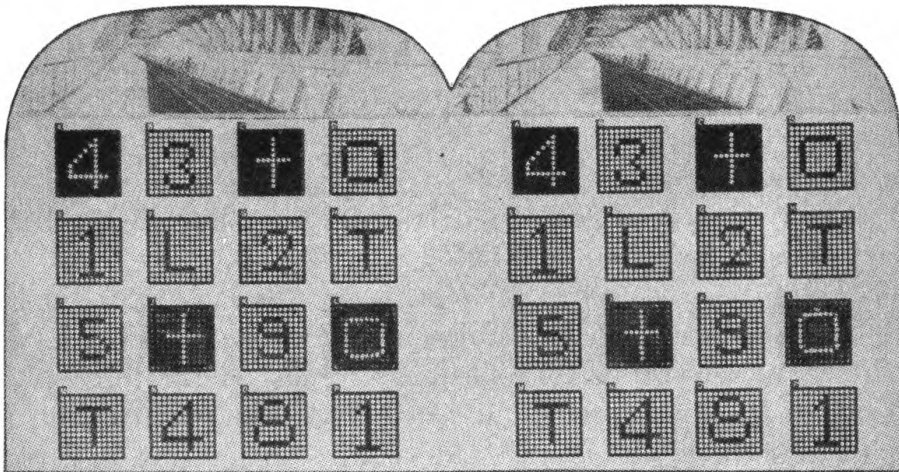


FIGURE 16.—Stereoscopic tester M1A1 slide.

(b) The subject is then asked, "What character or figure do you see in square A?" "In square B?" and all the other squares in order. See record form for correct replies which should be checked.

(c) It is not necessary for the subject to give the colors but it is more convincing if the reply is, for example, "A green 4 in a red background." Correct and rapid replies for A to H, inclusive, indicate sufficient color discrimination for the use of red, green, or yellow and blue flags and light signals. Correct and rapid replies for I to P indicate a higher discrimination of tints and shade of these colors.

(d) As soon as the test is completed, transfer this slide to the back of the pack which will then be in order for the next subject to be tested.

**14. Tests with DC series.**—a. The DC series of slides consists of 23 cards and is designed for testing and training of stereo-acuity



with the results measured in percent stereopsis, the relationship between percent stereopsis and the ability to judge a difference of convergence angles being shown in the table in paragraph 9e.

b. Each slide (fig. 17) contains three rows of various-sized numbers and letters, the middle row so positioned that the subject's visual axis

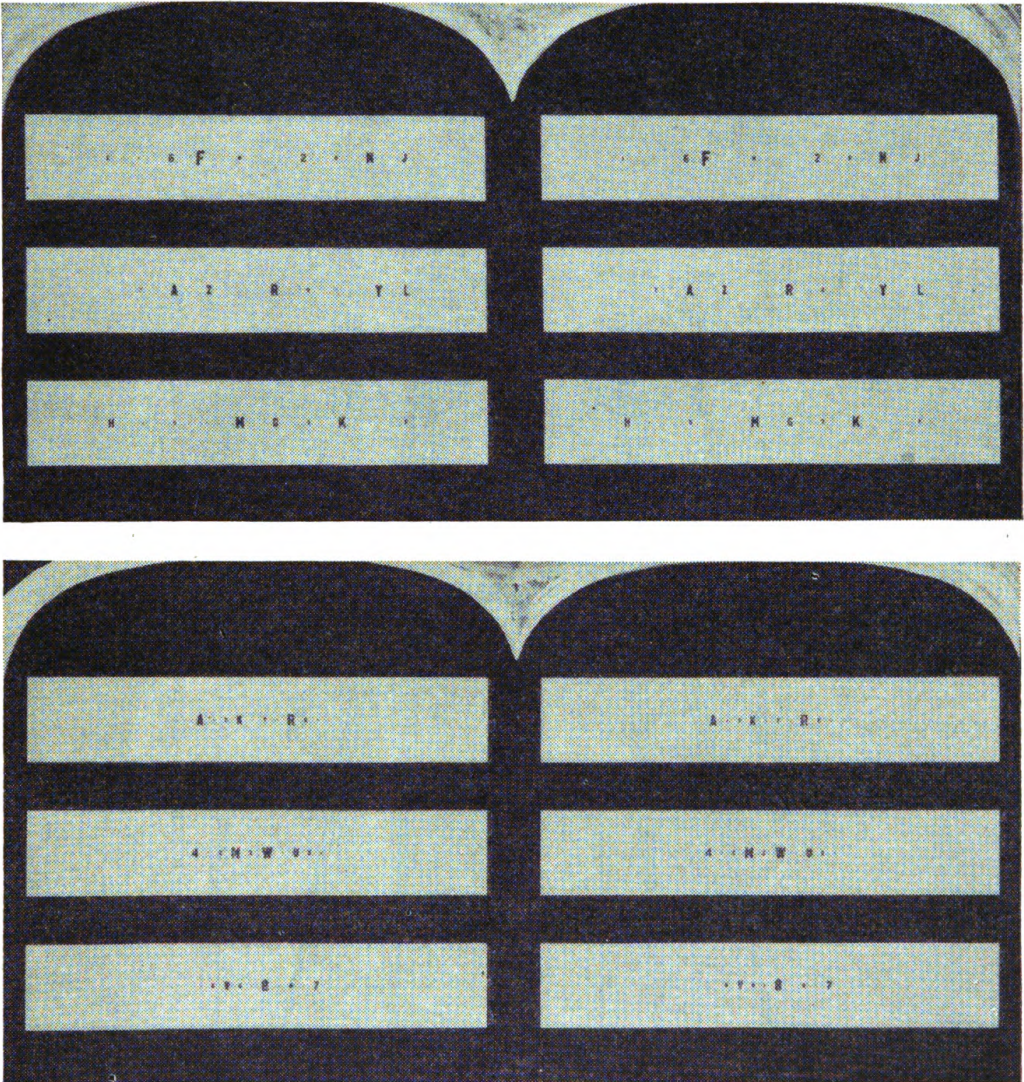


FIGURE 17.—Stereoscopic tester M1A1 slides.

lies in a horizontal plane. The upper row is positioned for an elevated visual axis and the lower row for a depressed visual axis.

c. The numbers and figures are of four different sizes, photographed stereoscopically, so that when viewed through the binocular, one letter or figure in each row will appear standing out from the others.

d. The size of the letter or figure, which appears standing in front of the others is given on the key plate (fig. 19), and the form on

which the instructor records the readings of the subject is also illustrated in figure 19.

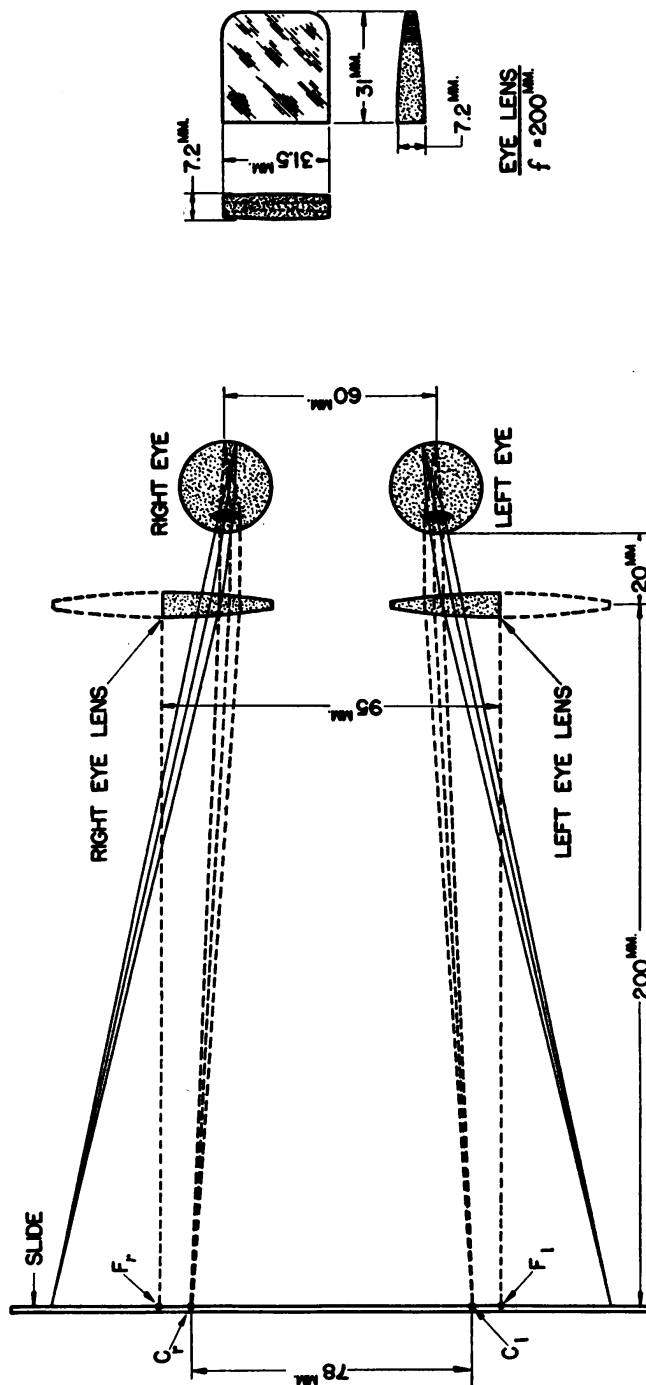


FIGURE 18.—Stereoscopic tester M1A1 optical system.

e. The DC unit may be used as a refined test of stereopsis, as an exercise for improving stereopsis, or as a tonic test preceding duty,



but these tests need not necessarily be given at the same time that the DB tests are given.

f. The purpose of the DC test is to aid in the selection of those who are best fitted visually to use instruments requiring a high degree of stereoscopic discrimination. It is equally valuable in determining the visual qualification necessary for aviators, drivers of all types

KEYSTONE DIAGNOSTIC SERIES				
STEREOMETRIC SECTION				
SLIDE No.	TOP	MIDDLE	BOTTOM	PER CENT STEREOPSIS
1	F $\frac{20}{120}$	Y $\frac{20}{90}$	V $\frac{20}{25}$	1%
2	G $\frac{20}{90}$	B $\frac{20}{25}$	L $\frac{20}{120}$	5%
3	2 $\frac{20}{120}$	8 $\frac{20}{50}$	Z $\frac{20}{120}$	10%
4	7 $\frac{20}{25}$	L $\frac{20}{50}$	S $\frac{20}{120}$	15%
5	X $\frac{20}{50}$	4 $\frac{20}{120}$	H $\frac{20}{120}$	20%
6	Z $\frac{20}{90}$	R $\frac{20}{120}$	A $\frac{20}{25}$	25%
7	M $\frac{20}{90}$	V $\frac{20}{25}$	C $\frac{20}{120}$	30%
8	U $\frac{20}{120}$	F $\frac{20}{25}$	J $\frac{20}{90}$	35%
9	4 $\frac{20}{25}$	A $\frac{20}{90}$	R $\frac{20}{50}$	40%
10	3 $\frac{20}{25}$	Y $\frac{20}{120}$	H $\frac{20}{50}$	45%
11	0 $\frac{20}{25}$	T $\frac{20}{120}$	M $\frac{20}{50}$	50%
12	C $\frac{20}{25}$	V $\frac{20}{50}$	E $\frac{20}{120}$	55%
13	2 $\frac{20}{90}$	U $\frac{20}{25}$	B $\frac{20}{50}$	60%
14	S $\frac{20}{25}$	T $\frac{20}{120}$	K $\frac{20}{50}$	65%
15	7 $\frac{20}{90}$	3 $\frac{20}{50}$	Z $\frac{20}{25}$	70%
16	N $\frac{20}{120}$	0 $\frac{20}{25}$	F $\frac{20}{50}$	75%
17	L $\frac{20}{90}$	C $\frac{20}{50}$	W $\frac{20}{25}$	80%
18	V $\frac{20}{25}$	H $\frac{20}{120}$	Q $\frac{20}{90}$	85%
19	3 $\frac{20}{25}$	D $\frac{20}{90}$	C $\frac{20}{120}$	90%
20	K $\frac{20}{50}$	F $\frac{20}{25}$	A $\frac{20}{120}$	95%
21	B $\frac{20}{120}$	A $\frac{20}{50}$	U $\frac{20}{25}$	100%
22	7 $\frac{20}{25}$	Z $\frac{20}{120}$	R $\frac{20}{50}$	105%
23	D $\frac{20}{25}$	U $\frac{20}{90}$	6 $\frac{20}{50}$	110%

THE FRACTIONS REPRESENT APPROXIMATE VISUAL ACUITY REQUIRED TO RECOGNIZE EACH LETTER  
THE LARGE LETTERS REQUIRE 20/50 OR LESS VISION.

① Key plate.

### STEREOMETRIC RECORD FORM FOR TESTER M1A1

#### DC Series of Slides

Set Slide Holder at 30—1.25

NAME \_\_\_\_\_

Date \_\_\_\_\_ 19\_\_\_\_

#### ODD NUMBERS (TEST)

Slide No.	Top	Middle	Bottom	Stereopsis
1				1%—1300 sec.
3				10%— 600 sec.
5				20%— 360 sec.
7				30%— 210 sec.
9				40%— 140 sec.
11				50%— 85 sec.
13				60%— 75 sec.
15				70%— 55 sec.
17*				80%— 39 sec.
19				90%— 26 sec.
21				100%— 19 sec.
23				110%— 10 sec.

\*To pass the test, Slide No. 17 must be read correctly.

#### EVEN NUMBERS (TRAINING)

Slide No.	Top	Middle	Bottom	Stereopsis
2				5%—870 sec.
4				15%—440 sec.
6				25%—286 sec.
8				35%—175 sec.
10				45%—115 sec.
12				55%— 80 sec.
14				65%— 65 sec.
16				75%— 45 sec.
18				85%— 32 sec.
20				95%— 21 sec.
22				105%— 13 sec.

② Record form (DC series).

FIGURE 19.—Stereoscopic tester M1A1.

of vehicles, and operators of moving equipment where errors in judging clearances may result in damage to property or person.

g. Only those who have successfully passed the DB tests, particularly test 11, are at all likely to be successful with the DC test. The tests are performed as follows:

(1) Adjust the stereoscope to the height of the subject's eyes and to a normal reading angle as for the DB tests.

(2) Arrange the odd numbered slides (1-3-5, etc.) in order from 1 to 23, faces up, in a pile near the instrument with the key plate conveniently located.

(3) Place 4 or 5 slides in the slide holder with DC-1 nearest the eyes. Always keep the same number of slides in the holder by placing the top slide from the pile, at the back of the pack in the slide holder, whenever a slide is removed from the front of the pack.

(4) Adjust the slide holder back and forth on the calibrated shaft to the position most satisfactory to the subject. The percents as indicated on the key are valid with the slide holder at 30-1.25-160 on the shaft, and this position should be used unless the subject can see the slides more clearly at some other position. Percentages are increased slightly when the tests are taken with the slide holder farther out than 30-1.25-160.

(5) The instructor asks, "What letter or figure appears to float in front of the slide in the top line? In the middle line? In the bottom line?" It is not necessary to record each reply. Simply note whether the replies are correct by referring to the key plate.

(6) Now remove slide DC-1 and lay it face down on the table, meanwhile placing the slide from the top of the pile behind all the others in the slide holder, and ask the same questions as before. Compare the replies with the key and continue to change the slides and take replies until at least two of the answers for any one slide are wrong. If the subject has given one erroneous answer for any lower numbered slide, repeat that slide. If the correct answer is then given for this slide, consider it as *passed*.

(7) The score for the day is the percent on the key corresponding to the last correct replies for all three lines on any one slide. Enter the score on the record form. The same test may be repeated after an interval of at least 1 week if desired.

*h.* (1) Daily exercises for the improvement of stereopsis may be taken without supervision if a telebinocular or good hand stereoscope is provided for the subject.

(2) The even-numbered group (2, 4, 6, etc., to 22), called the *training unit*, can be issued to the trainee together with a pad of stereometric record forms M-DC-11 and a telebinocular or stereoscope. He should be instructed in the use of the slides as already given with the additional instruction to keep an accurate record each day on one of the blanks from the pad.



(3) At stated intervals these forms should be returned and carefully compared with the key. Progress can thus be easily determined.

### STEREOSCOPIC TESTER M1A1 RECORD FORM

Name and Rank .....		
Btry. .... Regt. ....		
Date .....	Time .....	Examiner .....

SLIDE HOLDER AT ∞-00		
Test 1, Slide A. Visual Efficiency, Binocular		
1 2 3 4 5 6 7 8 9 10 11		
R L C B T C L B C L R		
Test 2, Slide B. Visual Efficiency, Left Eye		
1 2 3 4 5 6 7 8 9 10 11		
T B C R L C B R C B R		
Test 3, Slide C. Visual Efficiency, Right Eye		
1 2 3 4 5 6 7 8 9 10 11		
R L C B T C L B C L R		
Test 4, Slide D. Fusion at Distance—	3, 4 then 3	2, 4, 3 then 4
	Pass	Fail
Test 5, Slide E. Vertical Imbalance	-Θ-	0 0
	pass	fail
Test 6, Slide F. Lateral Imbalance at Far Point		
Arrow points to 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15.		
CHANGE SLIDE HOLDER TO 16-1.50		
Test 7, Slide F. Lateral Imbalance at Near Point		
Arrow points to 1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15.		
Test 8, Slide G. Fusion at Near Point—	3, 4 then 3	2, 4, 3 then 4
	Pass	Fail
Test 9, Slide H. Ametropia at Near Point		
Check vertical pair when one is clear, the other blurred	A <sub>3</sub> B <sub>4</sub> C <sub>4</sub> D <sub>3</sub> E <sub>2</sub> F <sub>4</sub> Right Eye	U <sub>2</sub> V <sub>4</sub> W <sub>4</sub> X <sub>3</sub> Y <sub>2</sub> Z <sub>4</sub> Left Eye
Also check when any not in pairs are blurred.		
CHANGE SLIDE HOLDER TO END OF SHAFT. THEN TO ∞-00		
Test 10, Slide I. Ametropia at Far Point		
Check vertical pair when one is clear, the other blurred	A <sub>4</sub> B <sub>3</sub> C <sub>3</sub> D <sub>4</sub> E <sub>4</sub> F <sub>2</sub> Right Eye	U <sub>4</sub> V <sub>2</sub> W <sub>3</sub> X <sub>4</sub> Y <sub>4</sub> Z <sub>3</sub> Left Eye
Test 11, Slide J. Stereopsis, or Depth Perception		
1 + 2. ● 3. ★ 4. ● 5. □ 6. □ 7. ● 8. + 9. ★ 10. +		
Test 12, Slide K. Color Discrimination		
A B C D E F G H I J K L M N O P		
4 3 + 0 1 L 2 T 5 + 9 0 T 4 8 1		
All correct to pass colors		All correct to pass tints
Stereometric Test Slides DC 1 to 23		
1st test ..... % 2nd test ..... % 3rd test ..... % 4th test ..... %		
date ..... date ..... date ..... date .....		

FIGURE 20.—Stereoscopic tester M1A1, DB record form.

(4) The forms should not be returned to the trainee nor should the key ever be shown to him. This will prevent any memorization or undesirable dissemination of information.

(5) The accuracy of the report may be checked by the examiner, if desired, who should use the short test (odd-numbered slides) thus avoiding all duplication.

i. A rapid review of the training unit immediately preceding duty requiring accurate stereopsis will act as an excellent tonic and will also reveal any possible transitory deterioration of stereopsis which might lower the efficiency of the subject temporarily.

**15. Use of special target slide.**—*a.* The special target slide (fig. 9) when used with the stereoscopic tester M1A1 will enable the prospective observer to appreciate what stereoscopic contact is and how it is secured before he attempts to operate the range or height finder. By means of the range scale and micrometer the instructor can determine the relative accuracy with which the candidate is making contacts.

*b.* The slide when used with the tester M1A1 employs the same ranging system as is used in the standard stereoscopic range and height finder, that is, a fixed reticle and a moving target. The elements of the fixed reticle are drawn so that they are seen at various ranges as in the range finder. The target image is inscribed on a strip of transparent celluloid that can be moved over the reticle by means of the range knob (fig. 9).

*c.* Turning this knob causes the target image to appear to move toward or away from the observer. It can thus be moved over the reticle until it appears to be at the same range as the measuring symbol of the reticle.

*d.* Only those who have successfully passed the DB tests and the DC tests should be permitted to use the target training slide. It provides a readily available means for keeping qualified observers in training when the use of the range finder is not practicable or not available.

*e.* The slide should be used as follows:

(1) The target should be set so that it will not appear in the same plane as the center symbol on the reticle (by turning the range knob so that scale and micrometer do not read zero-zero).

(2) Place the target slide in the slide holder and move the holder back and forth until it is properly focused for the observer candidate, then fasten the slide holder to the shaft.

(3) Now tell the subject to range the target until it appears to be in the same plane as the central symbol on the reticle. This is done by turning the range knob.

(4) When the subject thinks he has the target in the same plane as the central reticle symbol, the instructor should check his accuracy by

referring to the range scale and the micrometer. When the airplane is exactly in the plane of the central reticle symbol the scale and micrometer will read zero. When it is in the forward plane it will be indicated on the red readings of the scale and when in the rear, on the white markings.

(5) By constant use of this slide the subject will be able to familiarize himself with the stereoscopic effect as seen through the range or height finder, and the instructor can note his progress by means of the range scale and micrometer. If a candidate had a reading of approximately "5" one week and the following week obtained a reading of "2" it would indicate definite improvement of stereoscopic vision.

f. Trained observers may use the slide as an exerciser also, in the following manner:

(1) By trying to repeat certain readings, that is, to move the target image to different planes that are not in the plane of the central reticle symbol, noting the reading. Displace the image, and then range the target again to repeat the same reading, by noting the relation of the target image to the marks on the reticle.

(2) As an exerciser for promoting muscular coordination of the eyes for lateral balance by keeping the airplane on the target fused with the airplane on the reticle throughout the lateral movement of the target slide both to the right and left of zero.

## SECTION IV

### ADJUSTMENTS

	Paragraph
Telebinocular .....	16
Target .....	17

**16. Telebinocular.**—*a.* Fiber washers are inserted between the jaws of the elevating arm (fig. 2) and the swinging yoke. After constant usage these washers might become worn and need replacement to insure the clamping action between the jaws of the arm and the yoke.

*b.* In case the telebinocular does not maintain a position of balance it will be necessary to tighten the axle screw, or if it does not move with reasonable pressure on the lower portion of the swinging yoke, it will be necessary to loosen the axle screw.

(1) Before attempting to turn the axle it is necessary to loosen the small axle setscrew in the front of the jaw of the arm (not shown in figures).

(2) After adjusting the axle, tighten the setscrew again. This prevents the axle from turning when moving the swinging yoke to change the angle of the binocular.

**17. Target.**—The micrometer on the target slide can be adjusted to agree with the range scale by loosening the three screws and turning the micrometer to the desired setting and then tightening the screws again.

## SECTION V

### CARE AND PRESERVATION

	Paragraph
Lubrication-----	18
Cleaning-----	19
Handling and storage-----	20
Caution-----	21

**18. Lubrication.**—*a.* Very little lubrication will be required on this instrument. The bearing in the foot of the elevating arm should be lubricated with oil, lubricating, for aircraft instruments and machine guns. There is a small oil hole in the base of the arm, on the side opposite the handle, for this purpose. The arm must be collapsed however to bring the hole in position for oiling.

*b.* A little oil, lubricating, for aircraft instruments and machine guns might be required occasionally on the lead screw of the target to insure easy motion of the nut along the screw.

**19. Cleaning.**—*a.* Do not touch or attempt to clean the lenses with the fingers or an oily cloth. A clean, dry camel's-hair brush or a tuft of lens tissue should be used to remove particles of dust and grit from the lens surfaces.

*b.* The slides and special target slide should be kept free of dust and moisture, and should be wiped off before being used because any dirt or smears on the slides will affect the visual efficiency of the tests.

**20. Handling and storage.**—*a.* The stereoscopic tester M1A1 is not a very delicate instrument but it can be damaged when used carelessly by inexperienced operators. Reasonable care should be exercised in handling it, because the design of the stand is such that if dropped or knocked over the elevating arm might snap.

*b.* The observing instrument could be bent or deranged very easily; the eye shields are made of a brittle material and if bent cannot be straightened. A fall might bend or break the graduated shaft, slide holder, or lamp.



*c.* Each set of slides is provided with a box in which they should be kept when not in use. A box is also furnished for the special target slide. (See fig. 10.)

*d.* When the instrument is not being used or is being moved it should be collapsed and put in the metal carrying case provided for it.

**21. Caution.**—*a.* Do not attempt to change the angle of the binocular by taking hold of the end of the shaft. Always grip the handle end of the swinging yoke whenever making this adjustment.

*b.* Do not use oil on the fibre washers.

*c.* Be sure to loosen the handle of the clamping mechanism before attempting to elevate or lower the telebinocular by moving the elevating arm. After adjusting to the proper height be sure to tighten the handle again.

*d.* Be sure the slotted screw and the thumbscrew in the yoke are reasonably tight before using the instrument.

*e.* Be sure the tangent screw is tightened sufficiently to hold the slide holder to the shaft before inserting the slides.

*f.* Care should be exercised at all times to see that all setscrews and thumbscrews are reasonably tight before using the instrument.

## SECTION VI

### DEFINITIONS

Applicable terms-----	Paragraph 22
-----------------------	-----------------

**22. Applicable terms.**—*a. Abduction.*—Abduction is the power of the external muscles to turn the eyes outward. The subject is comfortably seated and told to look at a point "P" of steady light at a distance of about 6 meters as illustrated in figure 21. This point is slightly below the level of the subject's eyes, never above the level. In this position prisms of various refracting angles, with their bases inward, are placed in front of one or both eyes until the subject sees two lights in the horizontal plane and very close together. The strength of the prism or prisms thus placed before the eyes which will just permit the eyes to see one point, and if increased would produce diplopia, represents the power of the external recti muscles. This is spoken of as the power of abduction. For example, if with 7 prism diopters, base in, the eyes see two points, and with 6 prism diopters only one light, then 6 prism diopters represent the amount of abduction.

*b. Accommodation.*—Accommodation is the automatic adjustment of the eye for seeing distinctly objects at different distances. The range or power of accommodation may be defined as the difference

between the refraction of the eye in a state of rest (or adapted for its far point) and in a condition of maximum refraction, (or adapted for its near point). For example, an emmetropic (normal) eye has infinity for its far point, and if 10-cm distance is its near point, then the difference between the lens adapted for infinity and 10 cm will be 10 diopters, as 10 cm represent the focal length of 10 diopters. In other words, there is no accommodation used for infinity, but there is an accommodation of 10 diopters for the near point, which is the power of accommodation. The normal eye in a state of accommodation adds on to the front surface of the crystalline lens what is equivalent to a convex meniscus. Figure 22 shows an emmetropic eye at rest receiving parallel rays of light at a focus upon its retina,

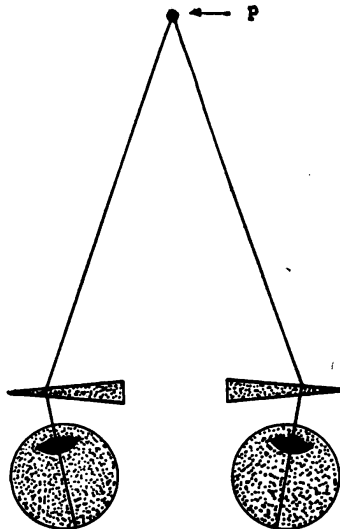


FIGURE 21.—Power of abduction.

and it also shows the same eye in its maximum state of accommodation for the point "P" at a distance of 10 cm, the dotted line representing what is equivalent to a convex meniscus, added to the front surface of the crystalline lens.

*c. Adduction.*—Adduction is the power of the internal recti muscles to turn the eyes inward. The power of the internal recti is tested in the same way as the power of the external (see *a* above), except that the prisms are placed base outward as illustrated in figure 23. For example, if with 19 prism diopters, base out, before the eyes two points are seen in the horizontal plane and with the 18 prism diopters only one point, then 18 prism diopters represent the power of adduction. In other words, as long as there is a prism of 18 or less than 19 prism diopters before the eyes, base outward in this case, the internal recti muscles can overcome the effect. It must be remembered

that the internal and external recti are antagonistic, and that the muscles of the two eyes are tested together. The relative power of adduction to abduction has been variously estimated, but most authorities are agreed that adduction is about three times that of abduction. The statement that adduction is three times as great as abduction in standard eyes applies particularly to subjects who pursue close occupations, whereas those who pursue an occupation that required dis-

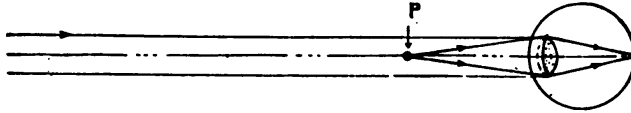


FIGURE 22.—Range of accommodation.

tant vision, sailors, soldiers, etc., may have adduction of only twice that of abduction and yet have what may be termed standard extra-ocular muscles. A close occupation, reading, writing, sewing, etc., develops the adduction power, and this is quite necessary at any prolonged close work.

*d. Ametropia.*—Ametropia is any abnormal condition of the refracting powers of the eyes, such as hypermetropia (farsightedness),

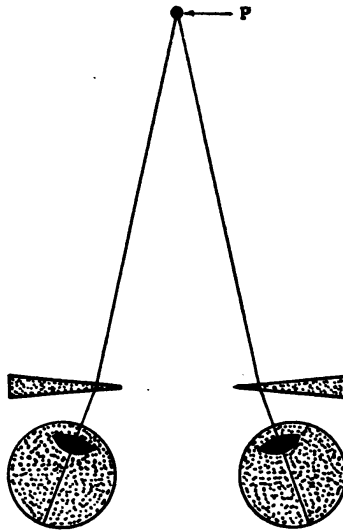


FIGURE 23.—Power of adduction.

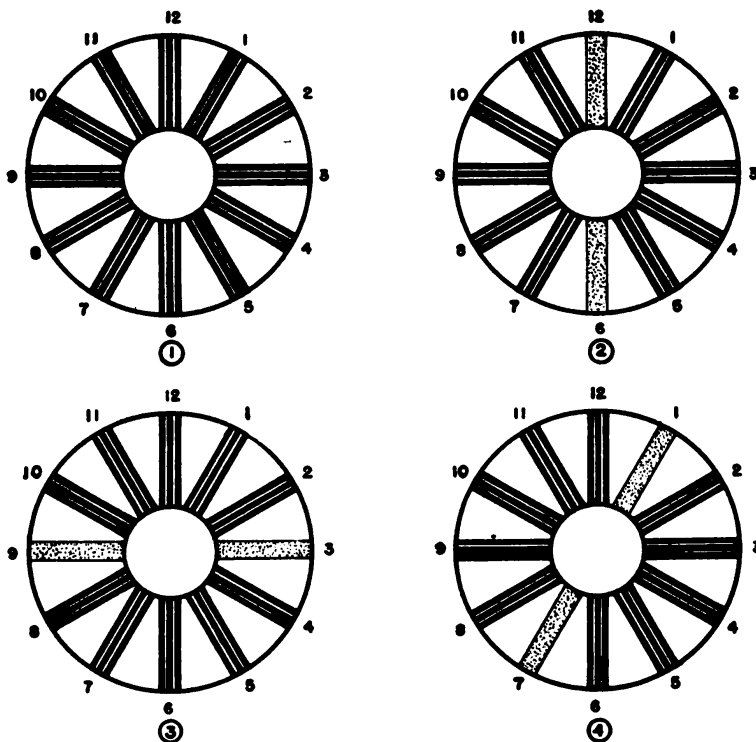
myopia (nearsightedness), or astigmatism. An ametropic eye is one which, in a state of rest, does not form a distinct image of distant objects upon its retina. An eye which is not emmetropic (normal) is ametropic.

*e. Asthenopia.*—Asthenopia is weakness or rapid fatigue upon exertion of the visual organs, accompanied by pains in the eyes and



headache. Asthenopia is a disease, and is often spoken of as "weak sight," "eye-strain," or "eye-stretching."

*f. Astigmatism.*—Astigmatism is a defect of the eye in consequence of which the rays of light derived from one point are not brought to a single focal point, thus causing imperfect images or indistinctness of vision. The term is applied especially to the defect causing images of lines having a certain direction to be indistinctly seen, while those of lines transverse to the former are distinctly seen.



① "Clock-dial" astigmatic chart. ②, ③, and ④ Appearance of chart to astigmatic eye.

FIGURE 24.—Astigmatism.

(1) The astigmatism of the eye is tested with the aid of an astigmatic chart. Ordinarily, the "clock-dial" chart, illustrated in figure 24①, will answer every purpose. This is a white card (a black card with white lines is also used) with peripheral Arabic characters corresponding to the characters on the clock face. From these figures a series of three parallel and uniformly black lines, with interspaces of the same width as the lines, cross from 1 to 7, 2 to 8, 3 to 9, 4 to 10, 5 to 11, and 6 to 12. This chart should be so calculated that at a given distance the angular widths of the lines and interspaces are equal to 5 minutes of arc.

(2) If the vertical lines from 6 to 12 (fig. 24②) appear indistinct, then it is the vertical meridian ( $90^\circ$ ) of the eye which is

astigmatic. Or if the lines from 3 to 9 (fig. 24③) appear indistinct, then the horizontal meridian ( $0^\circ$  or  $180^\circ$ ) of the eye is astigmatic. In figure 24④ the lines from 1 to 7 appear indistinct, hence the  $120^\circ$  meridian of the eye is astigmatic.

*g. Convergence.*—Convergence is the power particularly of the internal recti muscles to turn the eyes toward the median line—to “fix” an object closer than infinity as shown in figure 25. Normal eyes, when looking at an object of 6 meters or more, are not supposed to converge; the visual lines are spoken of as parallel and the power of convergence is in a state of repose.

*h. Diplopia.*—Diplopia is a double vision of a single object point when constituting a disorder of the eye. In figure 27① the right eye is shown fixed upon the object point  $P$  and the image of this point

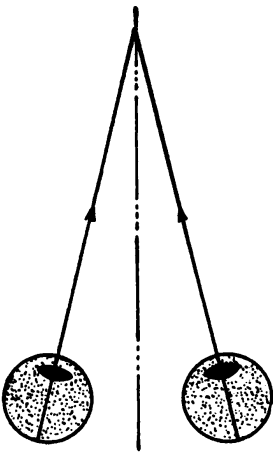


FIGURE 25.—Convergence.

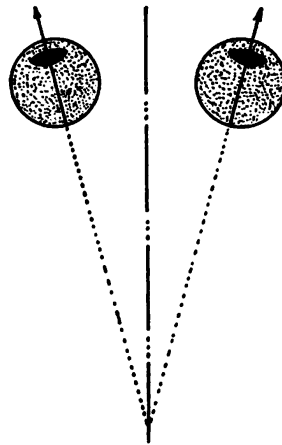


FIGURE 26.—Divergence.

will fall on the fovea  $F$  of the right eye. The left eye, however, is turned inward in the direction  $F-D$ , so that the image of the point  $P$  falls upon the retina to the nasal side of the fovea at  $E$ . The result is that the left eye sees a false object to the left of the real object. This condition is called direct or homonymous diplopia. The right eye shown in figure 27② is fixed upon the object point  $P$ , whose image will fall on the fovea at  $F$ . The left eye is turned outward in the direction  $F-D$  and the image of the point  $P$  will fall upon the retina to the temporal side of the fovea at  $E$ , with the result that the left eye sees false objects to the right of the real object. This condition is spoken of as crossed or heteronymous diplopia.

*i. Divergence.*—Divergence is the power particularly of the external recti muscles to turn the eyes outward so that the visual lines appear to be coming from a common center behind the retina of the eye as illustrated in figure 26.

*j. Emmetropia.*—Emmetropia is the normal refractive condition of the eye, or an eye which has reached that stage of development where parallel rays of light will be focused at the fovea F on its retina without any effort of accommodation. In figure 28 there is illustrated the path of the parallel rays in an emmetropic eye.

*k. Esophoria.*—Esophoria is heterophoria in which the visual lines tend inward as shown in figure 29①.

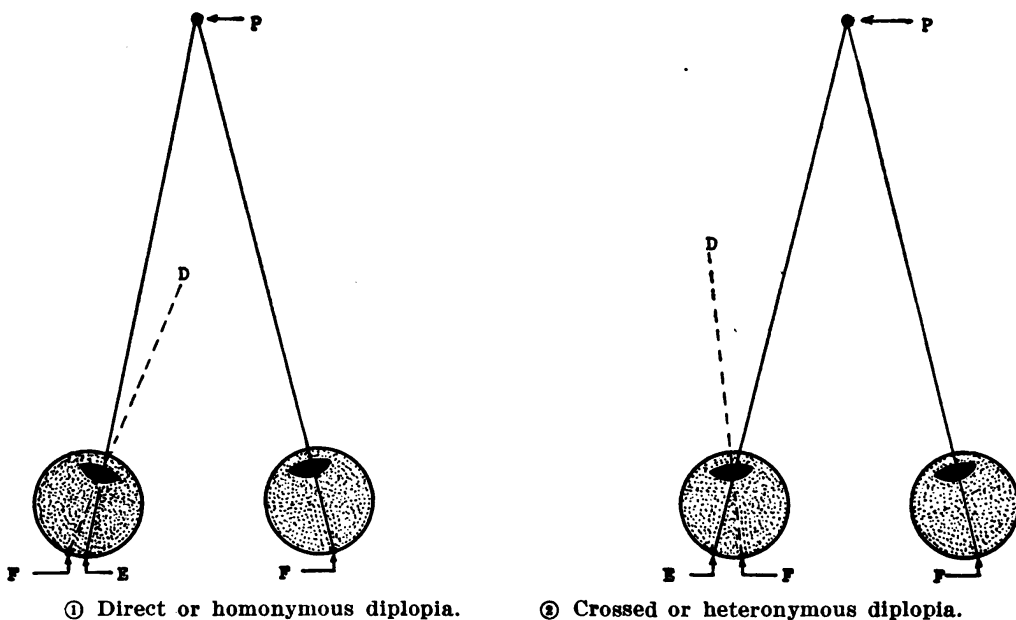


FIGURE 27.—Diplopia.

*l. Exophoria.*—Exophoria is heterophoria in which the visual lines tend outward as illustrated in figure 29②.

*m. Heterophoria.*—Heterophoria is the tendency of the visual rays to take, with passive adjustment, some other relation than parallelism but permitting binocular vision.

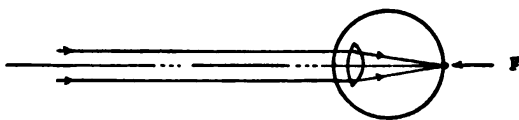


FIGURE 28.—Emmetropic (normal) eye.

*n. Hyperopia.*—Hyperopia describes an eye which is less than the standard measurements. About 20 percent of all eyes have simple hyperopia. The hyperopic eye is spoken of as farsighted, and the condition as one of farsightedness. Parallel rays of light passing into a hyperopic eye in a state of rest will fall upon its retina or fovea F before they come to a focus as shown in figure 30. A hyper-



opic eye is one which must accommodate for infinity and, in fact, for all distances.

*o. Hyperphoria.*—Hyperphoria is a tendency of the visual axis of one eye to be above that of the other. In order to test for hyperphoria take a white card and draw in the center a black circle, about 1 inch in diameter; through the center of this circle draw a black line about 12 inches long. The test chart thus prepared (fig.

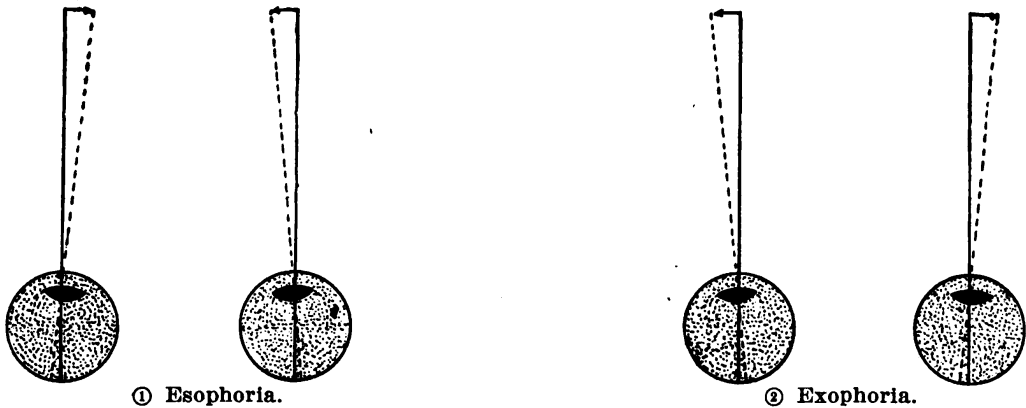


FIGURE 29.—Heterophoria.

31①) is then placed at a distance of 6 meters from the eyes, the circle being on the level with the subject's eyes. Place a 10 prism-diopter prism, base in, before the left eye, then the left circle belongs to the left eye. If the two circles seen appear in the horizontal meridian as illustrated in figure 31②, there is no vertical deviation. If the left circle is lower than the right then there is left hyperphoria. If the left circle is higher than the right then there is right hyper-

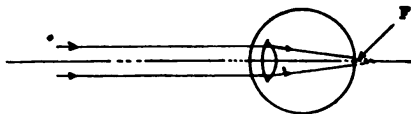


FIGURE 30.—Hyperopic (farsighted) eye.

phoria. The last two cases are illustrated in figure 31③ and figure 31④, respectively.

*p. Imbalance.*—Whenever there is any disturbance in the power, strength, or innervation of the ocular muscle or muscles, the condition is no longer one of equipoise, or equilibrium, or muscle balance, but is spoken of as muscular imbalance (heteropia). From this statement it must not be supposed that the two eyes cannot simultaneously “fix” an object, any more than it must be supposed that a hyperopic eye cannot see or have 20/20 vision without correcting lenses.

*q. Macula.*—The macular region on the retina is the part of the eye-ground immediately surrounding the fovea; it contains minute capillaries but it is impossible in healthy eyes to recognize them with the ophthalmoscope.

*r. Myopia.*—The myopic eye is spoken of as nearsighted, or short-sighted, and the condition as one of nearsightedness. About 1.5 per cent of all eyes have simple myopia. Parallel rays of light entering a myopic eye will focus in the vitreous humor before they reach the fovea F as shown in figure 32. A myopic eye is one which does not accommodate for distance.

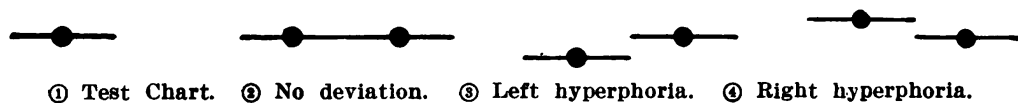


FIGURE 31.—Hyperphoria.

*s. Ophthalmic.*—Pertaining to the eye.

*t. Orthophoria.*—Normally, when both eyes “fix” the object, each eye has an image of the object on its fovea, and these foveal images or impressions are transmitted to the brain and fused as one image in the visual centers. This condition is spoken of as equipoise or orthophoria and the eyes are said to be in equilibrium or to be balanced.

*u. Orthoptic.*—Pertaining to or securing normal binocular vision as orthoptic exercises in which the ocular muscles are exercised by

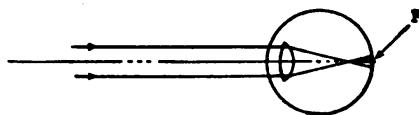


FIGURE 32.—Myopic (nearsighted) eye.

means of prisms or forced movements of the eyes in order to correct ocular deviation.

*v. Paralysis.*—Paralysis is the abolition of function, whether complete or partial, of one or more muscles of the eye.

*w. Presbyopia.*—Presbyopia is a defect of vision due to advancing age. Subjects at the age of 45 or more years are universally recognized as presbyopes, and the condition of their eyes as presbyopic. It is due to rigidity of the crystalline lens, which produces difficulty of accommodation and recession of the near point of vision, so that objects very near the eyes cannot be seen distinctly without convex lenses.

*x. Prism diopter.*—The unit of one prism diopter ( $\Delta$ ) is a prism which will deviate a ray of light just 1 centimeter for each meter of distance that it travels. The prism diopter is strictly a tangent measurement as illustrated in figure 33. As the deviation of a prism diopter is always 1 centimeter for each meter of distance, then 1 prism diopter will deviate a ray of light 2 centimeters for a distance of 2 meters, 3 centimeters for a distance of 3 meters, etc.

*y. Stereo-acuity.*—Stereo-acuity is the degree of sharpness of images seen with both eyes or it may be stated as the degree of keenness of stereoscopic vision.

*z. Strabismus.*—Strabismus is also known as “squint” or “cross-eye,” and is an affection of the eye in which the optic axes cannot be directed to the same object, due to undue contraction or undue relaxation of one or more muscles of the eyeball. The eye which has the image of the object on its fovea is spoken of as the fixing eye, while the other eye is termed the squinting or deviating eye.

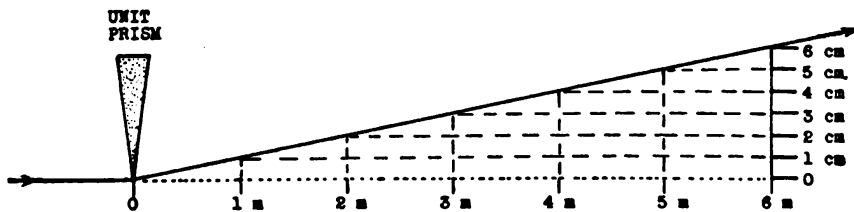


FIGURE 33.—Prism power—1 centimeter of deviation for each meter of distance.

*aa. Vision.*—Vision is the sense by which light and color are apprehended. The organ of vision is the eye which is so constructed as to serve as a camera obscura for the projection of images upon the retina, thus enabling perception of form.

*ab. Visual acuity.*—The standard acuteness of vision is the power of the eye to distinguish letters and characters occupying a square that is 5 minutes of arc each way, that is, each letter is so proportioned that it will measure exactly 5 feet in the vertical and horizontal meridians. Letters or characters made on this scale are called standard letters. For example, letters to be seen under an angle of 5 feet at a distance of 20 feet, or 6,096 millimeters, would have to be  $6,096 \times 0.0014544 = 8.86$  millimeters square (the natural tangent of 5 feet is equal to 0.0014544) and at 120 feet, or 36,576 millimeters,  $36,576 \times 0.0014544 = 53.2$  millimeters square. The record of the visual acuity is usually made in the form of fractions, using Arabic figures when the distances are expressed in feet. The fractions may read as follows: 20/20, 20/25, 20/50, 20/90, 20/120, etc., where the denominator indi-



cates the size of the letter which the eye can read at that particular distance. For example, the fraction 20/20 indicates that the eye can see clearly a letter 8.86 millimeters square placed at a distance of 20 feet from the eye, while the fraction 20/120 indicates that the letter must be 53.2 millimeters square if the eye is to see it distinctly at a distance of 20 feet.

*ac. Vision, binocular.*—If both eyes are used simultaneously when viewing an object we speak of binocular vision.

STEREOSCOPIC TESTER M1A1

APPENDIX

LIST OF REFERENCES

1. Technical manuals.

Stereoscopic range and height finding----- TM 4-250  
 Trainer, stereoscopic, M2----- TM 9-2654

2. Standard nomenclature lists.

Tester, stereoscopic, M1, parts and equipment-- SNL F-168  
 Current Standard Nomenclature Lists are as  
 tabulated here. An up-to-date list of SNL's  
 is maintained as the "Ordnance Publications  
 for Supply Index"----- (OPSI)

3. Text book.

"Refraction of the Human Eye and Methods  
 of Estimating the Refraction," by James  
 Thorington, A. M., M. D., Philadelphia, 1916.

[A. G. 062.11 (3-27-41).]

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